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Population Monitoring and Status of the California Red-Legged Frog (*Rana aurora draytonii*) and Unarmored Threespine Stickleback (*Gasterosteus aculeatus williamsoni*) in the Angeles National Forest, 2003

Technical Report

Prepared for:
Bill Brown - Angeles National Forest

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

Population Monitoring and Status of the California Red-Legged Frog (*Rana aurora draytonii*) and Unarmored Threespine Stickleback (*Gasterosteus aculeatus williamsoni*) in the Angeles National Forest, 2003

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INTRODUCTION

The California red-legged frog (*Rana aurora draytonii*, hereafter CRLF) and unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*, hereafter UTS) are listed under the Endangered Species Act, as threatened and endangered respectively (USFWS, 1970, 1996). Both species were historically abundant throughout southern California. Within Los Angeles County the CRLF is now restricted to a small portion of the upper Santa Clara River drainage in San Francisquito Canyon where critical habitat has been designated within the watershed (USFWS, 2000). Decline of the CRLF has mainly been attributed to loss of habitat, and introduction of exotic species (Jennings and Hayes, 1994). The UTS are restricted to several tributaries of the Santa Clara River including San Francisquito Canyon, Bouquet Canyon, and Soledad Canyon. The decline of the stickleback is mainly attributed to channelization of stream habitat linked with urbanization (Bell, 1978). The remaining populations of this endangered fish face many threats including urban development, high storm flows and dewatering of habitats where they occur outside the boundaries of the Angeles National Forest (Moyle, 2002). Within the forest boundaries, pollution, predation by non-native species, and exotic diseases are the primary threats to this species. From fall of 1999 to the present, the U.S. Geological Survey (USGS), Western Ecological Research Center has been monitoring the CRLF population in the San Francisquito Canyon watershed. USGS surveys for UTS in San Francisquito and Bouquet Canyon began in 2001.

On June 5, 2002, the Copper Fire in Los Angeles County burned just over 20,000 acres in San Francisquito Canyon and the surrounding area. The fire was contained June 11, 2002. Within San Francisquito Canyon, the fire burned reaches of the creek, which currently support populations of the threatened CRLF and the endangered UTS. Following the fire, these reaches were immediately resurveyed to assess the effects of the burn upon the resident populations of both CRLF and UTS, and their habitat (Hitchcock *et al*., 2002). Our assessment led to several management actions to alleviate further deterioration of habitat from predicted increases in runoff and debris during seasonal rains. These management actions included measuring pool morphology changes, and constructing an upstream catchment basin as well as three artificial CRLF pools. The

treatments are described in detail in a separate report (Compton *et al*., 2003); however the results are relevant to our population monitoring and therefore will be incorporated and referenced in this report as well. We also monitored water chemistry to characterize any changes associated with the Copper Fire.

The surveys summarized herein are a continuation of our previous work with an emphasis on population status following major habitat changes, as well as water chemistry and flow changes as a result of the Copper Fire in June, 2002. This report will also relate our post-fire management actions at San Francisquito Canyon (Compton *et al*., 2003) to CRLF and UTS habitat occupancy. Tables and figures for the CRLF, UTS and water quality have been placed in separate appendices to clarify which sections they correspond to. (Appendix 1 contains CRLF data, Appendix 2 contains UTS data and Appendix 3 contains water quality data).

STUDY SITE DESCRIPTION

The drainage of San Francisquito Canyon is divided into two reaches, Dam Reach to the north and Drinkwater Reach to the south (Appendix 1: Figure 1; Appendix 2: Figures 1-2). Each reach has an independent water source. Dam Reach is spring fed whereas Drinkwater Reach is mainly fed by Drinkwater Reservoir located on the hillside above the reach. These reaches share water only during significant rain events when the two reaches become connected by a stretch of creek bed that remains dry the remainder of the year. The CRLF population currently being monitored occurs in 1.2 km reach (Dam Reach) of San Francisquito Creek, whereas the UTS population occurs in both Dam Reach and Drinkwater Reach (Appendix 1: Figure 1). Our survey areas for UTS for 2003 were expanded to also include Soledad and Bouquet Canyons (Appendix 2: Figures 1, 3-4). Monitoring protocols for both species were recently updated to provide low impact means for acquiring data to track population trends and ensure the long-term persistence of these species in this area.

METHODS

CRLF Population Monitoring

The Dam Reach CRLF population was monitored using daytime and nighttime visual encounter surveys. Three types of surveys were conducted to monitor each of three life stages of the CRLF, (egg masses, tadpoles and adults). All surveys were conducted under Fish and Wildlife permit number TE-045994-3.

CRLF Egg Masses – Surveys for egg masses were conducted throughout all 36 pools. We surveyed each pool for egg masses seven times between January 13 and April 25. Surveys were conducted during the day by walking slowly upstream while taking care not to disturb too much sediment or walking along the banks when pools were too deep to walk through. When egg masses were found their locations were flagged and numbered, and general observations were recorded on the development of the larvae within each egg mass as well as the depth, size, attachment site and location of the egg mass within each pool (Appendix 1: Table 1). Each egg mass was labeled by pool name, and numbered sequentially as they were found (e.g., 1,2,3…) and by visit (a, b, c, etc.). For example an egg mass found in Long Pool was labeled LPem-01a for Long Pool egg mass number "1" visit "a." Egg mass locations were also recorded on a schematic map of the reach (Appendix 1: Figure 2).

CRLF Tadpoles – On June 17, June 18, and August 27 we sampled pools for tadpoles. Our objectives were to determine where successful breeding had occurred, and to monitor growth and development of larvae. Surveys were conducted during the day by targeting several pools that either had egg masses earlier in the year, or where we had previously observed tadpoles (Appendix1: Table 2). A pool was no longer surveyed when either we caught 20 tadpoles, or it was determined through dip-netting to exhaustion (repeatedly with no tadpole captures), that tadpoles were not present, or had metamorphosed. Up to 20 tadpoles per pool were caught with dip nets and placed in a 5-gallon bucket filled with water from the pool. For each tadpole we measured body length, total length, and Gosner stage (Dulleman and Trueb, 1986), checked the mouthparts for abnormalities, and then placed the tadpole in a second 5-gallon bucket of pool water. Tadpoles were released

back into the pool from which they were caught after all tadpoles captured from that pool had been processed.

CRLF Population Surveys – We visited each of the pools identified in Dam Reach during two nighttime sampling periods (sample 1: June 16-18; sample 2: August 25–27). Three consecutive nights were required in order to cover the entire CRLF habitat. Surveys began at Plunge Pool and pools were surveyed consecutively from southwest to northeast (from Plunge Pool to Tadpole Pool; Appendix 1: Table 3). The number of sampling periods was decreased from three in 2002 to two in 2003 because vegetation throughout the reach has grown extremely thick since the fire and is difficult to move through without startling the frogs. Therefore our population estimates were expected to be less accurate than in 2002 because more frogs avoided capture and marking in 2003. Each day before conducting the night survey, vegetation had to be removed with a machete in order for researchers to access the pools. An additional nighttime survey was conducted in Drinkwater Reach on July 28 to determine if frogs had migrated or winter rains had washed any frogs into this reach. Night surveys consisted of walking along the shoreline or through the center of larger pools searching for eye shine in the bank vegetation and along the pool margins. Our standard source of illumination is the Kohler® Wheat Lamp (45,000 candlepower). All frogs captured were weighed, measured, gender determined, checked for deformities, and scanned with a PIT-tag reader (Appendix 1: Table 4). Passive integrated transponder tags (PIT-tags) are injectable microchip identification tags, for frogs > 50 mm snout-vent length (SVL). We have been marking frogs in this manner at Dam Reach since 2000.

On two occasions (December 12, 2002 and April 14, 2003) during rain events we conducted supplemental nighttime road-riding surveys to detect dispersing CRLF (Dole, 1965; Semlitsch, 1985; Bury and Corn, 1991; Heyer *et al*., 1994; Bulger *et al.*, 2003). Road-riding was conducted by slowly driving back and forth along the road that runs adjacent San Francisquito Creek searching for eye shine in the road and on the margins of the road. On December 12, 2002 we also walked through the wash area west of Pools 8–14, to assess the increased flow of water through the area and determine if the CRLF use upland habitat in the rain.

UTS Population Monitoring

Study Sites – In the 2003 field survey, the study area was expanded from 2002 to include portions of Bouquet Canyon and Soledad Canyon as well as San Francisquito Canyon (Appendix 2: Figure 1). The San Francisquito site included all wetted portions of San Francisquito Canyon within the boundaries of the Angeles National Forest that are known to be inhabited by UTS (Appendix 2: Figure 2). The Bouquet Canyon site included 2.3 kilometers of wetted reach. Bouquet Creek flowed continuously from just below Bouquet Reservoir to the Forest Service boundary, and survey sub-sites were chosen within the flowing reach (Appendix 2: Figure 3). The survey reaches in San Francisquito and Bouquet were divided into 100 meter segments and presence/absence surveys for UTS were conducted in each reach (Appendix 2: Tables 1–3). The Soledad Canyon site included ~1 kilometer of reach that was intermittently wetted (Appendix 2: Figure 4). The Soledad Canyon site was not divided into 100 meter sections because sticklebacks were only ever detected in the extreme upper portions of the survey reach. The total occupied reach length was < 100 meters, and the survey reach appeared to be ephemerally wetted.

Survey Protocol – We recorded presence/absence within 100 meter segments in survey reaches using visual surveys plus netting (seine or dip-net). Based on previous work (Warburton and Fisher, 2002) seining and dip net surveys were chosen as the primary survey techniques, with visual surveys being used in a supplementary fashion when conditions were appropriate. Our survey effort to determine presence/absence within a reach was set at 10 seine or dip net hauls within a reach, or 10 minutes of active visual surveying. Visual surveying was only performed in reaches where conditions were suitable for this type of survey (clear, slow-moving water). Incidental observations of additional species were recorded during these surveys and each study site was surveyed three times during 2003.

Statistical Analysis – The proportion of sampling units occupied (100 meter reaches) at each site (Drinkwater Reach, Dam Reach, Bouquet Canyon) was calculated for each year using the Program PRESENCE, a proportion of area occupied estimator developed by (Mackenzie *et al*., 2002). The trial version of the computer software is available on the

web site: http://www.proteus.co.nz/. The program PRESENCE estimated the true proportion of sampling units occupied with an associated standard error in addition to the detection probability of the protocol given that stickleback were in fact present at a given site. The analysis assumes that a) no movement of fish was occurring between reaches between sample periods and b) that there are no changes in detection probability of the protocol between sample periods. Obviously it is possible that fish could move between 100m reaches and such movement could inflate the estimate of proportion of sampling units occupied. However we assumed such movement was minimal and will be automatically factored into the calculation of the detection probability. The results are interpreted as the estimated proportion of sampling units occupied during the season rather than during a single visit. The proportion of sampling units occupied was compared between years using a Z test where $\overline{X}_1$ and $\overline{X}_2$ are the estimated occupancy in years 1 and 2 respectively and SE is the standard error.

$$Z = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{SE_1^2 + SE_2^2}}$$

In the analysis of the Drinkwater site, SE for 2002 was substituted for the SE for 2003, since it was not possible to calculate the SE directly. Since the program PRESENCE is still a relatively new method of analysis and some violation of the assumptions was possible, the results were also checked by conducting a two-sample t-test for unequal variance to test for a difference in the average number of sampling units in which UTS were detected each year, using sampling periods as replicates. A third analysis was also conducted using Fisher's exact test (Zar, 1999) on a 2 x 2 contingency table (year, presence/absence) with sampling period treated as a strata variable using software *SAS System for Windows*, Release 8.02. The test was first conducted with all three sampling periods added together and then separately for each sampling period.

Plate Counts in Bouquet Canyon – In an effort to distinguish the subspecies of stickleback inhabiting Bouquet Canyon, preserved fish from this location were examined under a dissecting microscope, and their plates counted. This was an important determination because the unarmored threespine stickleback are federally endangered and not previously known from this location, whereas the partially armored threespine stickleback are considered to be introduced at this location and have no protective status.

Exotic Species Removal – During survey efforts to monitor stickleback, any exotic fish or macro-invertebrates (crayfish; *Procambarus clarkii*) encountered were removed. No special methods were employed during general surveys but a Smith-Root electro-shocker was used in locations known to have carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*). The electro-shocker was highly effective at immobilizing these species and helped to eradicate them from the areas they occupied.

Diseases – During the 2003 survey, specimens of rainbow trout (*Oncorhynchus mykiss*) caught in Bouquet Canyon were transported live to the Biology Department of San Diego State University where they were examined for parasites and gut contents by Dr. Victoria Matey. Parasite examination of all specimens included examination of fins, skin, gills, body cavity and major organs. Only live or freshly dead fish were examined. In addition, field examinations of captured fishes were conducted for external parasites.

Dr. Matey measured each fish (total and standard length in mm) and noted any wounds, deformities, scale abnormalities and tumors. Visual analysis was followed by a microscopic examination of mucus scrapings for parasitic protozoans. Body surface and eyes were examined visually and under the dissecting microscope for parasitic protozoans, crustaceans, and monogeneans. The nasal cavities were irrigated and resultant fluid was examined under the dissecting microscope. The fins, tail, and gills were examined visually and under the dissecting microscope followed by an examination under a compound microscope for parasitic protozoans, monogeneans, and crustaceans. All parasitic organisms found were collected, identified and counted separately. Parasites selected for light microscopy (LM) and scanning electron microscopy (SEM) were placed in appropriate fixative solutions.

Following visual examination, each fish was examined for internal parasites. First, the body cavity was opened and examined visually. Internal organs such as heart, liver, spleen, kidneys, gonads, gall bladder and swim bladder were dissected out, placed in separate containers and than dissected and examined using dissecting and compound microscopes. The gastrointestinal tract was removed, split from mouth to rectum and

examined for parasites in the lumen and attached to the walls. All helminths were collected, counted, examined with a dissecting and compound microscopes, and then fixed for LM and SEM.

Identification of parasites was based on the LM and SEM data. Specimens selected for LM were fixed in 70% ethanol, AFA, or 5% formalin, stained with hematoxylin, and examined with a Diastar microscope. Specimens of protozoans and helminths selected for SEM, were fixed in Karnovsky's solution, processed according to standard methods, and examined with a Hitachi S-2700 scanning electron microscope. Prevalence, mean intensity, abundance and infection sites for each parasite were determined for each species of parasite.

Water quality

Water quality monitoring efforts in San Francisquito can be divided into three groups. First, we monitored basic temperature status at several locations using Onset TidbiT temperature loggers. Second, we used four-parameter monitoring (pH, dissolved oxygen, conductance, temperature) at two fixed sites, using YSI 600XLM loggers. Third, we conducted nutrient analysis of water samples taken from the two fixed four-parameter monitoring sites. By comparing temperature, basic water quality parameters, and nutrient levels between sites before and after rain events we were able to form a fairly detailed description of the environmental parameters experienced by the aquatic fauna in San Francisquito Canyon.

Temperature Monitoring – For temperature monitoring in San Francisquito Canyon, we used Onset TidbiT temperature loggers, set to record temperature hourly, as well as the temperature function on the 4 parameter data loggers. Temperature monitoring at three pools in the Dam Reach and one pool in the Drinkwater Reach of San Francisquito Canyon (Appendix 3: Figure 1) began June 21st of 2002, and continued through January 8th of 2003. Loggers were tied to logs in pools known to contain California red-legged frogs using 30lb. test nylon monofilament line. All temperature loggers in the Dam Reach were lost in February of 2003 due to high winter flows.

Four Parameter Water Quality Monitoring – For basic water quality parameter logging in San Francisquito Canyon, we used YSI 600XLM four-parameter loggers set to record variables hourly. The variables collected included temperature, pH, dissolved oxygen and conductivity. Because of the delicate nature of the 600XLM probes, metal encasements were installed on or near bridge crossings in both the Dam Reach and the Drinkwater Reach (Appendix 3: Figure 1). The 600XLM required bi-weekly maintenance and calibration in order to assure accuracy of measured parameters. Four parameter monitoring began at one site in the Dam Reach and one site in the Drinkwater Reach on June 23rd of 2002, and has continued through the present. Data presented in this report are from June of 2002 to January of 2003.

Nutrient Analysis – In contrast to the other two techniques, which logged parameters hourly, nutrient analysis took place through laboratory analysis of water samples collected at discrete times. Water samples were analyzed for ammonia, nitrite, nitrate, phosphates, and major ions by the National Water Information System Laboratory and the data were incorporated into the USGS national water quality database. Nutrient samples were taken from the Dam Reach (Appendix 3: Figure 1) on 12/19/2000, 7/22/2002, 9/25/2002, 12/16/2002, and 10/20/2003. Nutrient Samples were taken from the Drinkwater Reach (Appendix 3: Figure 1) on 7/22/2002, 9/25/2002, 12/16/2002, and 10/20/2003.

San Francisquito Habitat Monitoring

Post-fire habitat changes were monitored and measured in San Francisquito Canyon from June 2002 to present. Methods regarding pool morphology measurements and the installation of the catchment basin and artificial pools are described in our treatment monitoring report (Compton *et al.*, 2003). Observations of pool morphology and stream channel changes were made during all surveys to assess the effectiveness of the catchment basin and artificial pools. Pool habitat suitability was also bio-assayed by presence of CRLF in the artificial pools, as well as habitat use and distribution of CRLF and UTS throughout San Francisquito Creek.

RESULTS

CRLF Population monitoring

CRLF Egg Masses – In 2003 a total of 28 different egg masses were documented in six distinct pools (Appendix 1: Figure 2). Seventeen of these were in Long Pool, which has been a successful breeding area in past years. Two were in Pool A1, two in Pool 15, two in Pool 8, three in Tadpole Pool, and two were found in Man Made Pool 1 (MM1; Appendix 1: Table 1). Although three egg masses were monitored and produced tadpoles at Fallen Willow Pool in 2002, no egg masses were found in this pool in 2003. Pool morphology changes in Fallen Willow Pool may have made this pool unsuitable for breeding this year (Compton *et al.*, 2003). The water temperatures during egg laying ranged from 9–15ºC. Eggs were documented on February 6, February 20, and March 7. Eggs were surveyed for but not detected on January 13, March 20, April 4, and April 25. After March 7 it appears that all observed egg masses were washed away by high winter flows. As of March 7 our egg mass surveys had not revealed any hatched embryos. However, we still surveyed for tadpoles because hatchlings could have dropped out of the egg masses before washing away.

CRLF Tadpoles – Tadpole surveys were conducted on June 16–17 and again on August 27 at pools where egg masses had been recorded and pools downstream of where egg masses had been found earlier in the season. Tadpoles were discovered only at Pool MM1. These were the only tadpoles recorded for the entire 2003 season. Neither tadpoles nor metamorphs were detected in any of the other pools surveyed throughout the season. Sixteen tadpoles were captured from Pool MM1 on June 18. Tadpole lengths (snout to tip of tail) ranged from 76–102 mm, body lengths (snout to vent) ranged from 32–38 mm, and Gosner stages ranged from 35–39. All 16 tadpoles appeared to be healthy with normal mouthparts (Appendix 1: Table 2).

CRLF Population Surveys – Most of our CRLF captures were made over the course of two main trapping periods. However, several incidental captures were made during surveys for egg masses, tadpoles, and general habitat assessments and will therefore be included in these results. Nearly half (23) of the 54 breeding adults captured between

December 16, 2002 and August 27, 2003 were also captured in 2002. (Juveniles were also captured and measured but were not included in the population estimates because they were not of breeding age. Therefore the total number of frogs caught during these surveys was 79). Only one breeding adult was captured twice in 2003. This frog moved from Plunge Pool to adjacent Overpass Pool (several meters away). A total of 139 frogs were either seen or heard jumping into the water and escaped capture. The vegetation has re-grown remarkably dense since the Copper Fire making it extremely difficult to approach the pools without startling the frogs. It is likely that frogs jumped into the water before we were close enough to hear them. This made our visual encounter estimations less accurate than last year. No new frogs were PIT-tagged in 2003 because we have reached the maximum allowable number of individuals for our USFWS permit. Our plot of body mass versus SVL for CRLF captures in 2003 can be used as a baseline of general health for this population and compared with subsequent years (Appendix 1: Figure 3). Although, the smallest age class (post-metamorphic frogs) is missing from these data because of poor recruitment.

Gaps in the age class structure of this population for 2003 can also be seen in our life stage observations chart (Appendix 1: Figure 4). These gaps are likely the result of winter rain events having washed away all of the egg masses of 2003. For example, as previously noted, no metamorphs from the 2003 breeding season were observed anywhere in the reach (Appendix 1: Table 4). Because we could not PIT-tag and because it was difficult to capture frogs in the thick vegetation in 2003, the population size estimates determined from last year's surveys (2002) represent the best possible estimates we are able to provide at this time. We had ideal conditions for estimating population size in 2002 because of the lack of vegetation and ease of locating and capturing frogs. Adult population estimates for 2002 were from about 200–500 frogs (larger than 50mm SVL; Hitchcock *et al*., 2002, 2003).

During the rain event of December 16, 2002 we found CLRF to be active and using upland habitat at least 40–50 meters away from the main pool areas where they are generally found on dry nights. Throughout approximately two hours of meandering through the habitat adjacent Pools 8–14, we observed eleven adult frogs and four

juveniles in the wet sandy wash. No CRLF were observed on the road this night or during a subsequent visit in the rain on April 14, 2003.

After winter rains, Dam Reach and Drinkwater Reach were connected for a short period of time (on and off for several months). A single adult CRLF was observed during the day at Drinkwater Reach, therefore a nighttime survey was conducted to see if frogs had migrated or washed into Drinkwater Reach. This nighttime survey revealed no CRLF in Drinkwater Reach, although we did rediscover one western pond turtle that had been captured, marked, and released in this reach by USGS in 2001. A brief survey was conducted at Stator Lane Bridge on July 29, 2003 because this area lies between Dam Reach and Drinkwater Reach and the CRLF had been observed at this location in 1999 by Tierra Madre Consultants, Inc., however we saw no signs of the CRLF here this season.

UTS Population Monitoring

Presence/Absence Surveys – Results from the test for differences in the proportion of sampling units occupied by UTS were summarized (Appendix 2: Tables 4–5). The two sites and the two different methods of analyses yielded similar results. Drinkwater Reach showed a strong decline in occupancy between 2002 and 2003 ($P = 0.0001$). Dam Reach also showed a significant decline in occupancy between years ($P = 0.0357$). Overall detection probability varied among the three sites from 0.57 at Bouquet Canyon to a high of 0.94 at the Dam Reach (Appendix 2: Tables 4–6). Although both Drinkwater Reach and Bouquet Canyon appear to show a decrease in occupancy as the season progressed, Dam Reach did not. There is insufficient data to determine if a within-season trend is occurring or not. A two-sample t-test yielded similar results to the proportion of sampling units occupied analysis (using the software program PRESENCE), thus providing further validation of the results.

In 2003 UTS were found in 7 of the 29 100m segments in San Francisquito Canyon, 21 of the 23 100m segments in Bouquet Canyon and in the one segment of Soledad Canyon. The complete results of six presence/absence surveys conducted in San Francisquito

Canyon and three presence/absence surveys conducted in Bouquet Canyon are summarized in Appendix 2: Tables 1–3.

Soledad Canyon – Because the Soledad Canyon Reach was ephemeral and sticklebacks were only ever found in the extreme upper portion of the reach, near the Forest Service boundary with private property, we could not apply the same methods that were used in Bouquet and San Francisquito Canyons. Sticklebacks were found in Soledad Canyon during all three visits to the site (8/1/03, 11/13/03, 12/10/03) but the animals observed were all very small (< 30mm), indicating that permanent wetted habitat capable of sustaining a population of stickleback was not present during the time of the survey within the Forest Service property boundary at this site.

Plate Counts in Bouquet Canyon – During 2001, 54 sticklebacks were collected from Zuni Campground in Bouquet canyon. Plate counts of these animals resulted in a bi-modal distribution, with 32 of the 54 being classified as unarmored (1–2 plates) as per Moyle (2002). It has been previously understood that the sticklebacks in Bouquet Canyon were partially armored individuals that had been planted with California Department of Fish and Game trout stocking activities (Camm Swift, pers. comm.). Partially armored sticklebacks currently have no protected status.

Feeding Analysis of Trout in Bouquet Canyon – In December of 2003, 56 rainbow trout (*Oncorhynchus mykiss*) were collected from Bouquet Canyon. These animals were collected from throughout the reach, and from areas where sticklebacks were detected as well. No sticklebacks were detected in the gut contents of the collected trout. The primary prey item appeared to be caddis-fly larvae (order Trichoptera), followed by snails (unidentified species), and then by various terrestrial insects.

Disease – In 2003 we observed the continuation of an outbreak of *Ichthyophthirius multifiliis* (Ich) in the Dam Reach that appeared to coincide with low flows and fall conditions during 2002. Visual observations during this time continue to indicate widespread infection of UTS by Ich throughout the reach. Other parasites commonly observed in San Francisquito such as black spot disease (trematode *sp. metacercaria*),

and anchor worm (*Lernea sp.*), were not detected during the 2003 season. We did not observe Ich infections in any other populations of stickleback covered in this study.

Water quality

Temperature Monitoring – Dam Reach temperature monitors at the following locations returned the following information: Dam Reach, Overpass Pool: for temperature readings from 6/10/02 to 11/15/02, the average temperature was 16.4ºC, the median temperature was 17.1ºC, the minimum temperature was 9.1ºC, and the maximum temperature was 24.1ºC. This is the pool beneath the San Francisquito road bridge. Dam Reach, Long Pool: for temperature readings from 6/10/02 to 11/15/02, the average temperature was 16.9ºC, the median temperature was 17.3ºC, the minimum temperature was 11.3ºC, and the maximum temperature was 22.0ºC. This is a pool below the dam where the majority of the red-legged frog eggs were recorded in previous years (Ervin *et al*., 2001; Hitchcock et *al.*, 2003). Dam Reach, Dam Pool: for temperature readings from 6/10/02 to 1/24/03, the average temperature was 14.9ºC, the median temperature was 15.5ºC, the minimum temperature was 1.3ºC, and the maximum temperature was 20.6ºC. This is the pool at the base of the remnants of the Saint Francis dam. These data are summarized in Appendix 3, Table 1.

Nutrient Analysis – Nutrient analysis of water samples taken from the Dam and Drinkwater Reaches prior to a rain event on 12/16/02 returned values believed to be associated with "normal" or baseline conditions for these areas. The sample taken following the rain event on 12/16/02 is reflective of storm flow conditions, which transported ash and other post burn detritus into the drainage, returning values between 10 and 100 times greater than the pre-storm samples for most variables. Nutrient levels for the Dam and Drinkwater Reaches are reported in the following tables and figures: Appendix 3: Table 2; Figures 2–3. Values marked with (<) are at or below lowest detectable levels.

Four Parameter Water Quality Monitoring –The YSI 600XL data logger installed at the Dam Reach Overpass Pool returned the following information for readings spanning

from June of 2002 to January of 2003, excluding data from the following dates; 6/21/02, 9/24/02-9/28/02, 10/7/02-10/16/02. These dates were excluded based on the observation that the sensor head of the logger lost contact with the water because of changes in water level at the location where the logger was installed. Average temperature was 15.8ºC; minimum was 7.2ºC and max was 26.0ºC (Appendix 3: Figure 4A). Differences in these measurements compared to those taken with the temperature monitors were due to the depth of the logger within the stream. Average specific conductivity was 960µs/mgl, minimum was 176 and maximum was 1487 (Appendix 3: Figure 5A). Average percent saturation of dissolved oxygen (D.O.) was 86%, minimum was 26% and maximum was 206% (Appendix 3: Figure 6A). Average pH was 8.0, minimum was 7.0 and maximum was 8.5 (Appendix 3: Figure 7A).

The YSI 600XL data logger installed at the Drinkwater Reach Overpass Pool returned the following information for readings spanning from June of 2002 to January of 2003 but excluding those date ranges that were also excluded for the Dam Reach: average temperature was 16.6ºC; minimum was 7.3ºC and max was 26.9ºC (Appendix 3: Figure 4B). Average specific conductivity was 372us/mgl, minimum was 121 and maximum was 523 (Appendix 3: Figure 5B). Average percent saturation of dissolved oxygen was 87%, minimum was 7% and maximum was 107% (Appendix 3: Figure 6B). Average pH was 8.1, minimum was 7.7 and maximum was 9.0 (Appendix 3: Figure 7B).

San Francisquito Habitat Monitoring

Dramatic pool morphology changes were observed in several of the pools in Dam Reach. For example Koi Pool and Pool X were completely filled in with debris after mid-December rains in 2002, but were flushed out again by a subsequent rain event (Hitchcock *et al.,* 2002). Half of Fallen Willow Pool was filled in with debris which never cleared. Changes to Drinkwater Reach pools were less noticeable. In our USGS treatment monitoring report, comparisons of pre- and post-rain event pool morphology in San Francisquito Canyon to data from similar sites in unburned creeks indicated that the fire resulted in increased alteration to morphology (Compton *et al.,* 2003). This report demonstrates that there were in fact changes to the habitat structure, but that the management actions decreased the severity of these changes. Similarly, the artificial

pools dug for this study were successful additional habitat because frogs occupied the artificial pools shortly after they were installed and breeding took place in one of them. The artificial pools were dug by the US Forest Service in late October 2002 and adult frogs were observed in MM1 and MM2 on November 14, 2002 and August 26, 2003, and in MM3 on June 17, 2003. The egg masses were observed in MM1 on March 7, 2003, and tadpoles in MM1 on June 18, 2003, further reinforcing the success of this management action.

DISCUSSION

The CRLF can currently be found in only two known locations, and has been seen in the last decade (but not in recent years) in two additional locations in southern California. The closest of these four populations to San Francisquito Canyon is at Ritter Ranch in Amargosa Creek over 25km away, but is likely extinct. Therefore, the closest known extant population holds an estimated 25 adults and is more than 50km away at Ahmanson Ranch in an area where political issues over development are being argued. Without monitoring and proper management these remaining populations could disappear. We have been monitoring the population of red-legged frogs in San Francisquito Canyon since 1999 to determine the status of this population and gather data relevant to the management and recovery of the CRLF. In the first years of our studies here we deduced that the population in this canyon was limited to the area below the remnants of Saint Francis Dam and our preliminary population estimates were between 50–100 adults. The population appeared relatively stable and healthy with all life stages observed (i.e., eggs, tadpoles, metamorphs, juveniles, and adults). In June of 2002 the Copper Fire burned most of the watershed for San Francisquito Canyon. Although this fire event revealed the CRLF population and habitat to be more than twice as extensive as what we had previously thought, it also emphasized the degree to which this isolated population is at risk of extirpation. There is clearly an urgency to sustain the remaining populations and come up with management plans to restore to historical populations. The San Francisquito frogs may be the only remaining population large enough to act as a source population to restore the CRLF to southern California.

CRLF Population monitoring

Surveys conducted during 2003 revealed that many if not most of the CRLF survived the 2002 burn. However, based on our experience in similar landscapes in southern California, we predicted that increased water and debris runoff in the years following the fire could be a bigger threat than the fire itself. Based on this prediction, the US Forest Service recommended the construction of a basin to capture debris upstream of the CRLF populations, and the construction of several small off-channel pools that would be less vulnerable to fire-related impacts. USGS recommended continued population monitoring to assess if our predictions were accurate, if management actions were successful, and to continue to track the status of this vulnerable population.

CRLF Egg Masses – Many frogs survived the burn and began breeding in February of 2003. All 28 egg masses observed in 2003 disappeared. These eggs apparently washed away during winter rain events, resulting in a poor recruitment year for the CRLF in San Francisquito Canyon. None-the-less we were able to map out preferred breeding sites of the CRLF for 2003. Because of this mapping, we found that Long Pool appears to be the favored breeding pool from year to year. Although indirect effects of the Copper Fire (increased runoff and debris) caused many changes in pool morphology throughout Dam Reach, Long Pool profiles did not change as much as many of the other pools in comparison (e.g., Fallen Willow Pool, Koi Pool, Pool X, Dam Pool; Appendix 1: Figure 5; Compton *et al*., 2003). Fallen Willow Pool in particular, appeared to be unsuitable for oviposition in 2003 likely because of debris deposition. This is unfortunate because this pool had successful recruitment in 2002.

CRLF Tadpoles – Tadpoles were found on only one occasion in one pool (MM1). Had the Forest Service not constructed these artificial pools, it is unlikely we would have witnessed any successful recruitment in 2003. Because these frogs are adapted to fire and flooding, one poor recruitment year should not threaten this healthy population. In addition the rapid recovery of under-story vegetation should reduce flows and the further introduction of debris to pools in the 2004 breeding season. Based on these observations we predict that egg masses laid in 2004 will be less subject to runoff, and that survival to metamorphosis will increase.

CRLF Population Surveys – Frogs of all age classes were extremely difficult to capture and count this year because the under-story vegetation had grown back so densely by the time these frogs were most active and surveys were conducted. For example in 2003, 79 adults and juveniles were captured (no metamorphs were ever found) and 139 escaped whereas in 2002, 242 adults, juveniles and metamorphs were captured and 114 escaped using the same protocol and surveying the same area. It is doubtful that we will have as good an opportunity to estimate the adult frog population size as we did in 2002 when all of the vegetation was absent. Future surveys for breeding adults will likely be as difficult as they were in 2003. However, our current protocol does allow us to determine the general health and persistence of these frogs in San Francisquito Creek, and we expect there to be no negative long-term effects of the Copper Fire on the CRLF population here.

UTS Population Monitoring

Population monitoring of UTS began soon after the Copper Fire, and has continued to the present (2002-2003). Earlier survey efforts were able to detect the species in all current survey locations (San Francisquito, Soledad, Bouquet) and these three locations are considered to be the entire known distribution of this animal on Forest Service land. The species faces several threats in these areas, including exotic diseases, competition with exotic species, and dewatering of habitat. Our data indicate that between 2002 and 2003 there was a decline in the San Francisquito Canyon population of UTS (Appendix 2: Table 1, 2, 4, and 5).

Percent Sites Occupied Survey Protocol – Based on our previous work (Warburton *et al.*, 2002) the detection techniques we used were appropriate for the species found in the areas we surveyed, allowing technicians to detect unarmored threespine stickleback and other aquatic species. By utilizing the percent sites occupied (PSO) methodology described earlier we were able to accomplish several goals associated with our monitoring effort. First, we were able to successfully track UTS occupancy throughout the survey areas while minimizing impacts to this fragile environment. Second, by avoiding density estimates at fixed locations and instead focusing on a measure of habitat

occupancy, we were able to provide more robust measurements of population health as well as detect trends in stickleback population dynamics. The protocol was not only able to detect the sharp decrease in occupancy at the Drinkwater site, but also the smaller but consistent change in occupancy which occurred at the Dam site.

Detection probability is a function of the abundance of a species at the sampling site as well as habitat complexity, and in our surveys detection probability differed across the three reaches. Using the PSO method we detected a dramatic (~50% in 2002 to ~0% in 2003) reduction in the habitat occupancy of UTS in Drinkwater Reach. We did detect a single animal in a single 100m section of the reach during the November 2003 sample period. Because of this detection we believe that stickleback have not been extirpated from the reach but are present in very low densities. One explanation may be that winter rains in 2002-2003 in combination with increased sedimentation caused by the Copper Fire created an environment that the stickleback had difficulty persisting in. Although occupancy of the Drinkwater site was strongly reduced, sticklebacks were not entirely eliminated from the reach and it will be interesting to see if this population is able to successfully rebound. The Dam Reach continued to support sticklebacks during this time and negative effects would have to have been limited to Drinkwater Reach only. This is plausible given the rapid response of Dam Reach riparian vegetation to the fire, as well as the physical differences between the two reaches. Because Dam Reach is generally deeper and slower flowing than Drinkwater Reach, the same level of sedimentation could have resulted in larger impacts in Drinkwater Reach simply because it could not absorb the additional sediment without changes to the physical characteristics of the reach. These changes would be typified by a reduction in deeper (> 30cm) pools and an increase in water velocity and are in line with observations on the ground.

Exotic Species Removal – We have removed more than 700 exotic animals from San Francisquito Canyon (Warburton *et al*. 2002). Unfortunately, the two greatest threats to UTS, mosquitofish (*Gambusia affinis*), and red swamp crayfish (*Precambarus clarkii*), are difficult to eradicate entirely. Both wetted reaches are downstream of the Green Valley community, in which several individuals operate private ponds. These ponds may serve as a source for the introduction of other exotic fish species and parasites for both

reaches. In addition, Drinkwater Reach is connected to the Drinkwater Reservoir, which may serve as an additional source of exotics for this reach. Without exotic eradication at potential source habitats, removal will require constant attention.

Differences Between Sites – Dam and Drinkwater Reaches of San Francisquito Canyon and the Bouquet Canyon survey reaches differed considerably in physical makeup, water quality parameters, and biotic composition (Appendix 2: Table 7). In general Drinkwater Reach is shallow with fewer pooling areas whereas Dam Reach has many deep (> 1.5m) pools. It is interesting to note that we have never detected mosquitofish in Drinkwater Reach. Dam Reach appears to be higher quality habitat based on the lower observed habitat occupancy by exotic species, but physical characteristics in this reach appear to favor the Ich parasite.

Diseases – In 1995 CDFG first reported *Ichthyophthirius multifiliis* (Ich) in UTS from San Francisquito Canyon (Chen, 1995). Starting in 2001 when USGS began work in the canyon, Ich has been detected each season, along with several other parasites including anchor worm and black spot disease. Significantly, Ich has only been detected in the Dam Reach, while anchor worm and black spot disease have been detected in both reaches. Although Ich is a highly virulent disease, capable of inducing die-offs, we have observed several interesting phenomena related to its effects and distribution in the canyon. First, it has been detected in Dam Reach but not Drinkwater Reach, even though these reaches are connected during high flows. Based on data from hatchery studies of the behavior of the Ich parasite, we theorize that the more channelized, swiftly flowing stream environment of Drinkwater Reach is unsuitable for the completion of the Ich parasite life cycle (Bodensteiner *et al*., 2000). In the 2003 season Ich infected animals were observed during all three site visits, countering previously assumed seasonal differences in intensity of the Ich infestation in this reach.

Water quality

Several remarkable differences were uncovered by water quality monitoring in San Francisquito Canyon. Differences can be divided into two categories: differences

between Dam Reach and Drinkwater Reach, and differences at both reaches pre and post rain event.

Our data indicate that Dam and Drinkwater Reaches differ substantially in the basic water quality parameters (temperature, dissolved oxygen, conductance, and pH). Dam Reach exhibited a wider temperature range than Drinkwater Reach and both showed the same basic trend of cooling in winter. Differences in dissolved oxygen were more distinct between reaches; with levels in Dam Reach fluctuating twice as much as in Drinkwater Reach (Appendix 3: Figure 6). Conductance indicated that Dam Reach was on average twice as mineralized as Drinkwater Reach (Appendix 3: Figure 5). This is almost undoubtedly due to anthropogenic sources in the form of a ~3–5 CFS input of water from the Owens Valley at the beginning of Drinkwater Reach. The Owens Valley water appears to be much less mineralized and is artificially depressing mineral levels at the sample location. Under natural conditions, Drinkwater Reach, being downstream, would be expected to be at least as mineralized as Dam Reach. The pH levels were similar but those in Dam Reach displayed a wider range (7.5–8.5) than in Drinkwater Reach (8.0–8.5) (Appendix 3: Figure 7).

These differences, especially temperature and dissolved oxygen, are in line with what would be expected based on the physical and biological composition of these reaches. Dam Reach is on average slower moving and more ponded, while Drinkwater Reach is more swiftly flowing and channelized. Nutrient levels were similar for the sites.
Pre and post rain event comparisons yielded alterations of both basic water quality parameters and nutrient levels. Alterations in basic water quality parameters were observed in conductivity, pH and D.O., while temperature showed little or no response to rain events. Conductivity at both reaches was affected by rain events, being depressed following rain events, and then gradually returning to stable values. There were slight depressions in recorded pH values at both sites following rain events but values rapidly returned to pre-event levels. Dissolved oxygen readings were depressed to near zero for a period of days following the 12/16/02 rain event for which nutrient samples were taken. It appears from the data that our data loggers were able to collect sustained readings between calibration and membrane replacement. In other environments the D.O.

membrane will often become fouled after a short (3–7 day) period, resulting in a steady decline in measured D.O. to a point where the reading becomes zero (Carmen Burton, USGS/WRD, pers. comm.) We observed no such drop in D.O. readings between calibrations that we would associate with fouling of the membrane over time and this was true for the instruments in both reaches.

Nutrient levels showed the largest differences in pre and post rain event comparisons, with all values increasing at least one order of magnitude (10X) and some values changing several orders (400X). Additional sampling in 2003 following the rain event showed nutrient levels back to their previous levels thus further suggesting that the Copper Fire affected nutrient levels. Under normal (non burn) conditions, run-off into the drainage would presumably produce much lower nutrient input levels. Additional sampling will be required to observe the long-range effects of this nutrient input.

In their paper on the effects of ammonia on rainbow trout, Thurston and Russo (1983) found LC50 (Lethal Concentration 50%) ammonia values ranged between 0.2 and 1.2 mg/l of ammonia. Our post-rain ammonia measurements for the Dam and Drinkwater Reaches both fell solidly within this lethal range (0.85mg/l; Appendix 3: Figure 2B). In a study of nitrate toxicity, Westin reported stickleback survived nitrate concentrations of 500-800 mg/l for up to 10 days, and further reported field values at springs of up to 10 mg/l (Westin, 1974). Even storm-flow nitrate measurements for San Francisquito were well below known harmful levels.

The storm-flow values reported for San Francisquito undoubtedly produced stressful conditions and may have contributed to higher mortality or even die-offs of sticklebacks and red-legged frog eggs and tadpoles. However the impacts were short term, and any animals that survived the degraded habitat conditions created by the storm-flow run-off would most likely not continue to be impacted by those events. This is not to say that the system is no longer in danger from such events.

San Francisquito Habitat Monitoring

After just one significant rain event the constructed catchment basin was 90% full (Bill

Brown, pers. comm.) None-the-less, pools downstream of the basin exhibited elevated morphological changes compared with sites in unburned areas. Had the Forest Service not installed the catchment basin we likely would have seen greater changes in pool morphology and the comparisions would almost certainly have been more dramatic. All of the silt and debris that settled out in the catchment basin would have presumably ended up in the CRLF and UTS habitat further altering the channel and pool morphology. Moreover, because morphology measurements were taken at only two points in time (once before the rains and once after), we likely underestimated the differences in changes (i.e., transient changes between these times) that occurred in the burned area.

The presence of adults, tadpoles and eggs in the constructed pools is evidence of the success of installing the pools. Because adults were found using the pools just one month after they were built, we should consider constructing pools in other areas where CRLF breeding habitat is limited or has been destroyed. Also, Pool MM1 was the only pool with successful recruitment (at least to the tadpole stage), which further provides evidence of the value of this post-fire treatment for the CRLF.

The less dramatic reduction of UTS observations in Dam Reach as compared with Drinkwater Reach suggests that the catchment basin may have provided relief to Dam Reach sticklebacks. Drinkwater Reach has a different water source and appears to have been affected by runoff more severely than Dam Reach. Since Drinkwater Reach is less pooled and more of a wash during rain events the high volume of runoff did not manifest itself in drastic pool morphology changes, but may have carried UTS into the wash areas that later dried.

MANAGEMENT RECOMMENDATIONS

CRLF Population Monitoring

Although we are optimistic about the long term persistence of the CRLF in San Francisquito Canyon, continued monitoring is essential. Because recruitment was generally unsuccessful in 2003, resurveying is necessary to determine that the habitat has recovered sufficiently from the fire to support a viable population of CRLF. As we are

increasingly recognizing, fires are a natural component of these systems, but one that may require related management actions to preserve critically imperiled species such as the CRLF. These management actions are often experimental, and monitoring is essential to determine their benefits to target species. Our data indicate that this location currently supports the single largest population of CRLF in southern California, emphasizing the need for continued monitoring and management.

Additional threats to the CRLF include exotic crayfish which inhabit the breeding areas and may be impacting embryo and tadpole survival. Crayfish are known to prey on ranid eggs (Saenz *et al.*, 2003) and could become a problem for future recruitment if their numbers increase in the breeding pools. Although crayfish are difficult to eliminate completely, we recommend that efforts be initiated to capture and remove crayfish. Minnow traps could be used to decrease the number of crayfish in CRLF breeding pools.

Unarmored Threespine Stickleback

Exotic species removal efforts have been very successful in eradicating exotic carp and goldfish from San Francisquito Canyon. These animals are highly visible, but have not been observed to reproduce in the system and persist only in small numbers. The likely source for these animals is private individuals releasing unwanted pets. This is also the likely source for the introduction of Ich and anchor worm, two parasite species that will probably remain indefinitely in San Francisquito Canyon. The release of unwanted pets in wild spaces will also remain a constant danger to the conservation of unarmored threespine stickleback in this area. These introductions are symptomatic of the much larger problem of the lack of education regarding the importance of conserving native species. Solutions to this problem are beyond the scope of our present work. Although complete eradication of exotic pest species such as crayfish and mosquitofish are unlikely because of reintroduction, reproduction, and practical limits to removal efforts, these species are still important to keep track of. Both likely affect reproductive success of the sensitive natives present in the drainage and their removal or reduction would be beneficial. Using the PSO technique we will continue to monitor the distribution of exotics in the reaches and it may be that substantial increases in the area occupied by these pest species would call for the implementation of control measures.

Exotic Plant Species Removal – Arundo donax is a major problem in the drainage. Stands of this introduced weed effectively excluded the researchers from surveying parts of Drinkwater Reach prior to the Copper Fire. The *Arundo* has responded so vigorously post fire that researchers were being excluded from these same reaches. However, large scale control measures have been implemented and we look forward to observing their effects on the fauna of Drinkwater Reach. Although *Arundo* has not yet become a serious problem in Dam Reach, continued efforts of early eradication are highly recommended.

Transplantation Experiment – The Power Station Reach of San Francisquito Canyon contains several kilometers of high quality habitat but does not currently possess unarmored threespine stickleback. This reach is similar to the Drinkwater Reach in its physical characteristics and gradient. We recommend that a group of unarmored threespine stickleback be moved from either Drinkwater or Dam Reach into the Power Station Reach in an effort to establish a third population in San Francisquito. Actual relocation efforts would not be resource intensive (1 day, 2 people) and could include measures to reduce the chances of spreading exotic diseases, although Ich has already been documented in the Power Station Reach. We strongly recommend that the U.S. Forest Service consider this translocation.

Water quality

Based on the data collected, there have been significant impacts to habitat quality due to the Copper Fire, but almost entirely via the mechanism of storm-flow run-off. Although these run-off events did negatively alter habitat quality, they were fairly short lived, and conditions rapidly returned to pre-storm levels.

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Appendix 1

California Red-Legged Frog

Appendix 1: Table 1. 2003 CRLF egg mass survey results.

Survey Date	Pool	Egg Mass ID	Diameter (cm)	Depth Below Surface (cm)	Depth of Water (cm)	Egg Mass Attached To	Heavily Silted	Date Recorded Missing
13-Jan-03				No egg masses found				
* 6-Feb-03	Pool A1	A1em-01					N	20-Feb-03
		A1em-02					N	20-Feb-03
	Long Pool	LPem-01					Y	20-Feb-03
		LPem-02					Y	20-Feb-03
		LPem-03					Y	20-Feb-03
		LPem-04	15				Y	20-Feb-03
		LPem-05					Y	20-Feb-03
		LPem-06					Y	20-Feb-03
		LPem-07					N	20-Feb-03
		LPem-08					Y	20-Feb-03
		LPem-09	6				Y	20-Feb-03
		LPem-10					Y	20-Feb-03
		LPem-11					Y	20-Feb-03
	Pool 15	P15em-01					Y	20-Feb-03
		P15em-02					Y	20-Feb-03
20-Feb-03	Long Pool	LPem-01a		1	50	dead willow branches	N	7-Mar-03
7-Mar-03	Long Pool	LPem-01b		40	45	dead willow branch	N	20-Mar-03
		LPem-02b		15	30	aquatic grass	Y	20-Mar-03
		LPem-03b		2	12	dead willow branch	N	20-Mar-03
		LPem-04b		on surface	35	aquatic grass	N	20-Mar-03
		LPem-05b		15	35	dead willow branch	Y	20-Mar-03
	Pool MM1	MM1em-01b		on surface	45	aquatic grass	N	20-Mar-03
		MM1em-02b		on surface	40	dead woody vegetation	N	20-Mar-03
	Pool 8	P8em-01b		1	1200	aquatic grass	N	20-Mar-03
		P8em-02b		20	1500	dead willow branch	Y	20-Mar-03
	Tadpole Pool	TPem-01b		on surface	20	aquatic grass	N	20-Mar-03
		TPem-02b		on surface	20	aquatic grass	N	3/20/2003 (only a tattered fragment remains)
		TPem-03b		on surface	15	root mass	N	20-Mar-03
20-Mar-03			No viable egg masses found - only a tattered fragment remains of TPem02b					
4-Apr-03				No egg masses found				
25-Apr-03				No egg masses found				

* Surveys on 6-Feb-03 were conducted before we decided to collect data on egg mass measurements therefore these data are missing. Following these first surveys we assigned letter (a, b, c, etc.) to each egg mass ID to indicate on which visit the data were recorded.

Appendix 1: Table 2. 2003 CRLF tadpole survey results.

Survey Date	Pool	Time (minutes)	# People Dip netting	Gosner Stage	Total Length (mm)	Body Length (mm)
17-Jun-03	Plunge Pool	5	4	No tadpoles		
	Fallen Willow Pool	5	4	No tadpoles		
	Long Pool	25	4	No tadpoles		
	Boulder Pool	15	4	No tadpoles		
	Pool 8	N/A	4	No tadpoles - too deep to sweep bottom		
18-Jun-03	Tadpole Pool	25	4	No tadpoles		
	Pool MM1	25	4	35	88	32
				36	76	34
				36	79	32
				37	92	37
				37	82	36
				37	102	36
				37	97	36
				37	97	36
				38	94	38
				38	96	35
				38	95	35
				38	101	36
				38	99	36
				39	98	33
				39	106	37
				39	102	38
27-Aug-03	Long Pool	N/A		No tadpoles		
	Pool MM1	N/A		No tadpoles		

N/A = exact time was not recorded in the datasheet.

Appendix 1: Table 3. Pool order and GPS locations.

Pool Name	Lat.	Long.
Plunge Pool	34.54585	-118.51660
Overpass Pool	34.54570	-118.51650
Fallen Willow Pool	34.54598	-118.51443
Riffles 1	34.54603	-118.51477
Long Pool	34.54630	-118.51400
Riffles 2	34.54652	-118.51347
Unnamed Pool	34.54650	-118.51313
Boulder Pool	34.54648	-118.51270
Dam Pool	34.54693	-118.51270
Crevice Pool	34.54687	-118.51242
Pool 0	34.54698	-118.51245
Pool 1	34.54700	-118.51222
Pool 2	34.54712	-118.51200
Pool 3	34.54747	-118.51202
Pool A1	34.54767	-118.51222
Pool A2	34.54778	-118.51228
Pool A3	34.54833	-118.51260
Pool 4	34.54768	-118.51178
Pool 5	34.54805	-118.51150
Pool 6	34.54821	-118.51142
Pool 7	34.54847	-118.51137
Pool 8	34.54868	-118.51102
Pool 9	34.54873	-118.51070
Pool 10	34.54877	-118.51058
Pool 11	34.54892	-118.51012
Pool 12	34.54885	-118.50998
Pool 13	34.54913	-118.50947
Pool 14	34.54922	-118.50888
Pool 15	34.54957	-118.50892
Pool D1	34.54935	-118.50918
Pool D2	34.54975	-118.50878
Pool MM1	34.54948	-118.50828
Pool MM2	34.54963	-118.50798
Pool MM3	34.54998	-118.50693
Pool X	34.55092	-118.50835
Koi Pool	34.55123	-118.50715
Tadpole Pool	34.55152	-118.50688

[1]All GPS coordinates recorded in WGS 84.

Appendix 1: Table 4. 2003 CRLF capture summary.

Survey Date	Survey Type	Pool	Age	Male / Female	Recapture	Animal ID	Length (mm)	Weight (g)	Notes
16-Dec-02	Nighttime road riding in rain and general habitat assessment	Flat wash area between Pool 8, Pool 14, and hill side to the west	Adult		7 escaped				
			Adult		Y	053337297			
			Adult		Y	052768765			
			Adult		Y	052835110			No CRLF observed on or near road
			Adult		Y	053834293			
			Juvenile		escaped				
			Juvenile		3 escaped				
13-Jan-03	Daytime, targeting eggs	Pool 15	Juvenile						
		Pool A3	Juvenile						
			Juvenile						
			Juvenile						
20-Feb-03	Daytime, targeting eggs	Pool D1	Juvenile						
			Juvenile						
7-Mar-03	Daytime, targeting eggs	Fallen Willow Pool	Adult						Seen resting on bottom of pool
		Pool 4	Juvenile						
		Pool A2	Adult						
4-Apr-03	Daytime, targeting eggs	Pool 15	Adult						
		Pool A3	Adult						Heard calling
		Pool D2	Adult						
14-Apr-03	Nighttime road riding in rain				No CRLF Observed				

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Appendix 1: Table 4. 2003 CRLF capture summary (continued).

Survey Date	Survey Type	Pool	Age	Male / Female	Recapture	Animal ID	Length (mm)	Weight (g)	Notes
25-Apr-03	Daytime, targeting eggs	Drinkwater Reach - Cattail Pool	Adult						
		Long Pool	Adult						
		Pool 2	Adult						
		Pool 4	Adult						Heard jumping into the water
		Pool 10	Juvenile						
		Pool 11	Juvenile						
		Pool A1	Adult						
		Pool A3	Juvenile						
		Pool C1	Juvenile						
		Pool D1	Juvenile						
16-Jun-03	Nighttime, targeting adults	Boulder Pool	Adult		escaped				
			Adult	M	N		88	83	
		Fallen Willow Pool	Adult		2 escaped				
		Long Pool	Adult		3 escaped				
			Adult	M	Y	058070295	86	66	
			Adult	M	Y	058085895	86	75	
		Plunge Pool	Adult		4 escaped				
			Adult	F	Y	058082093	79	85	
			Adult		Y	058040031	86	86	
			Adult	M	Y	058080861	79	71	
		Riffles 1	Adult		2 escaped				
			Adult	F	N		63	33	

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Appendix 1: Table 4. 2003 CRLF capture summary (continued).

Survey Date	Survey Type	Pool	Age	Male / Female	Recapture	Animal ID	Length (mm)	Weight (g)	Notes
16-Jun-03	Nighttime, targeting adults		Adult	F	N		71	42	Broken toe # 1000
		Riffles 2	Adult		3 escaped				
			Adult	F	N		66	36	
		Unnamed Pool	Adult		2 escaped				
17-Jun-03	Nighttime, targeting adults	Crevice Pool	Adult		escaped				
			Adult	F	N				
			Adult	F	Y	052618376	118	100	
		Dam Pool	Adult		escaped				
		Pool 2	Adult		escaped				
		Pool 3	Adult	F	N		68	33	
			Adult		escaped				
		Pool 4	Adult	F	N		95	95	Weight is approximate; Missing 400 and 500 toe
			Adult		escaped				
		Pool 5	Adult		4 escaped				
		Pool 7	Adult		escaped				
		Pool 8	Adult		8 escaped				
		Pool 8a	Adult		2 escaped				
		Pool 12	Adult		2 escaped				
		Pool 13	Adult		4 escaped				
		Pool 14	Adult		escaped				
		Pool 15	Adult		9 escaped				
		Pool A2	Adult	F	N		70	47	
		Pool A3	Adult		escaped				
		Pool D1	Adult		3 escaped				

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Appendix 1: Table 4. 2003 CRLF capture summary (continued).

Survey Date	Survey Type	Pool	Age	Male / Female	Recapture	Animal ID	Length (mm)	Weight (g)	Notes
17-Jun-03	Nighttime, targeting adults		Adult	F	Y	053378020	80	78	
			Juvenile	F	N		56	19	
			Juvenile	F	N		55	15	
		Pool D2			escaped				
			Adult	F	N		72	37	
		Pool MM3	Adult		escaped				
9-Jul-03	Daytime, general assessment	Catchment Basin	No CRLF Observed						
28-Jul-03	Nighttime, targeting adults	Drinkwater Reach	No CRLF Observed						
29-Jul-03	Daytime general assessment	Stator Lane Bridge	No CRLF Observed						
25-Aug-02	Nighttime, targeting adults	Boulder Pool	Adult	F	N		79	59	
			Adult		2 escaped				
			Adult	F	N		80	55	
			Adult	F	N		86	70	
			Adult	F	Y	058056365	104	115	
		Fallen Willow Pool	Adult		2 escaped				
			Adult		6 escaped				
			Adult	M	Y	058040031	91	83	
			Adult	M	Y	053268844	73	43	
		Long Pool	Adult		7 escaped				
			Adult	M	N		74	52	
		Overpass Pool	Adult	M	Y	058080861	93	78	
			Adult	M	Y	058083305	86	74	

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Appendix 1: Table 4. 2003 CRLF capture summary (continued).

Survey Date	Survey Type	Pool	Age	Male / Female	Recapture	Animal ID	Length (mm)	Weight (g)	Notes
25-Aug-02	Nighttime, targeting adults	Plunge Pool	Adult	F	N		91	77	
			Adult	F	Y	058067534	104	135	
			Adult	M	Y	058085515	84	68	
		Riffles 2	Adult	F	N		100	120	
			Adult	F	N		81	55	
		Unnamed Pool	Adult		escaped				
			Adult	F	N		86	73	
26-Aug-03	Nighttime, targeting adults	Boulder Pool	Adult	?	Y	058080573	96	76	
		Dam Pool	Adult	M	Y	410A0D4374	81	79	
		Crevice Pool	Adult		4 escaped				
		Pool 0	Adult		2 escaped				
			Adult	F	N		72	38	
		Pool 1	Adult	F	N		80	57	
			Adult		escaped				
		Pool 2	Adult		4 escaped				
		Pool 4	Adult	M	N		91	79	
			Juvenile	M	N		77	47	
		Pool 5	Adult	M	N		81	57	
			Adult		8 escaped				
			Adult	M	N		69	36	Left hind foot missing all toes. See photo.
			Adult	M	N		76	47	
		Pool 7	Adult		escaped				
		Pool 9	Adult	F	N		83	67	
			Adult		2 escaped				

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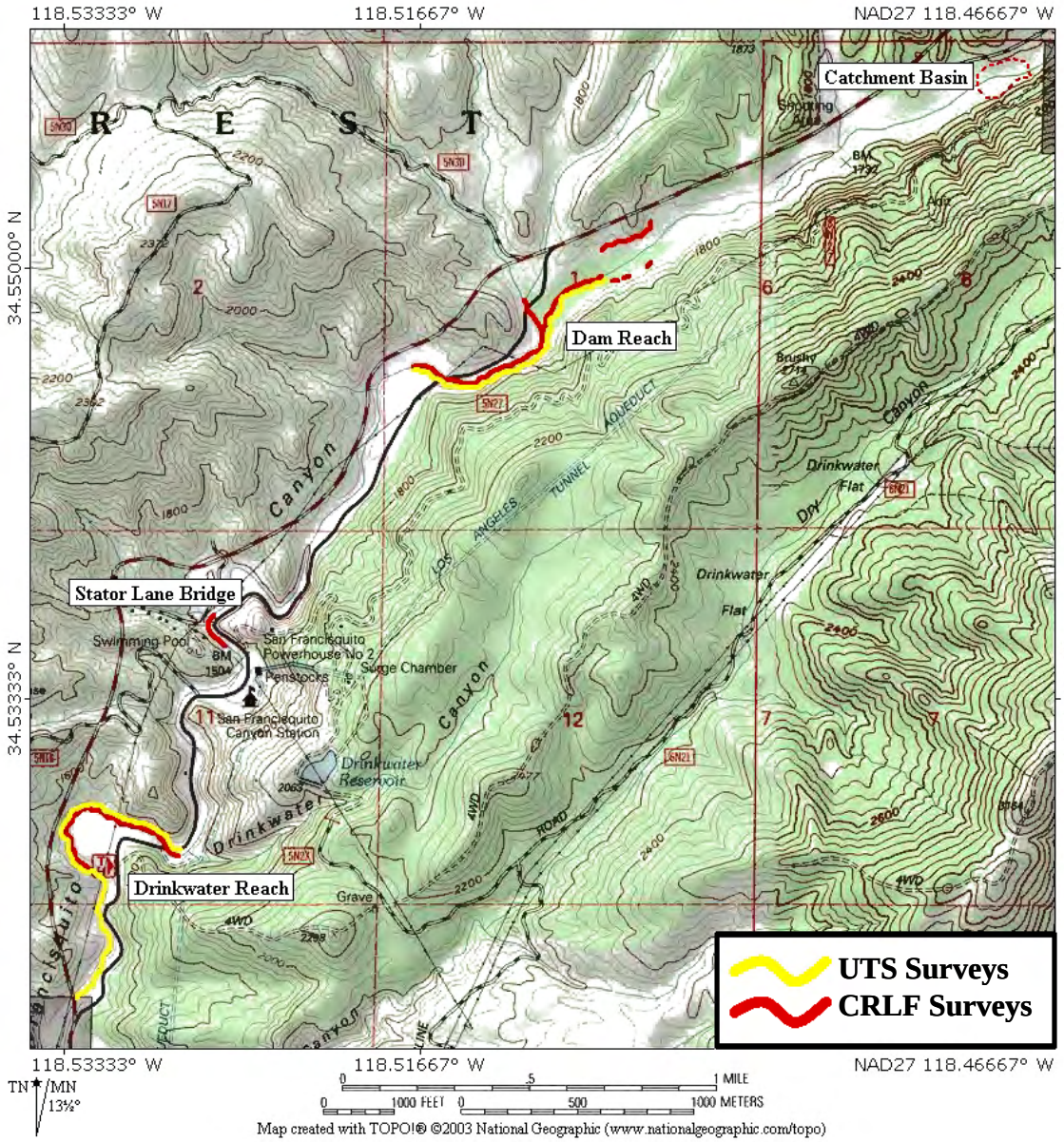
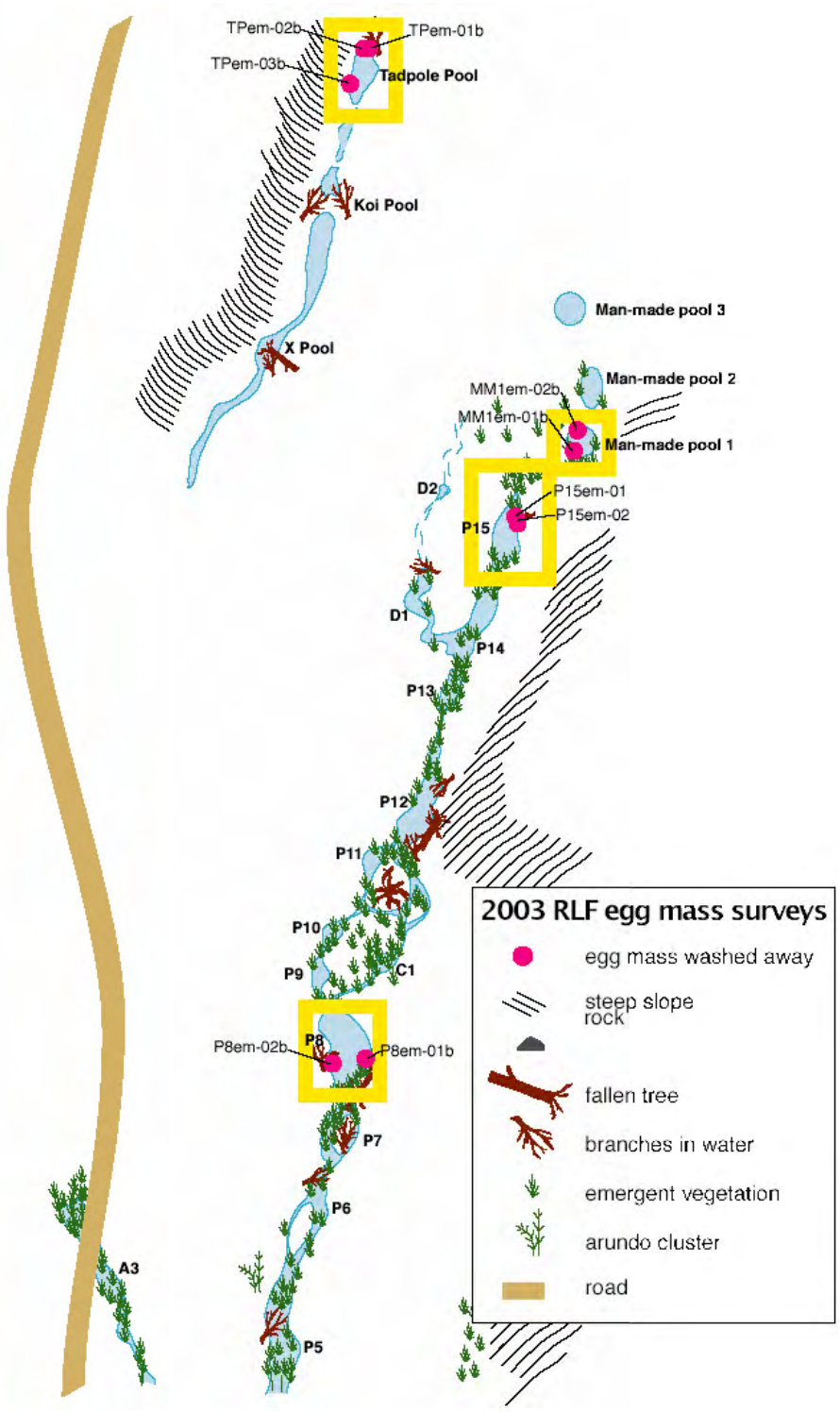
Appendix 1: Table 4. 2003 CRLF capture summary (continued).

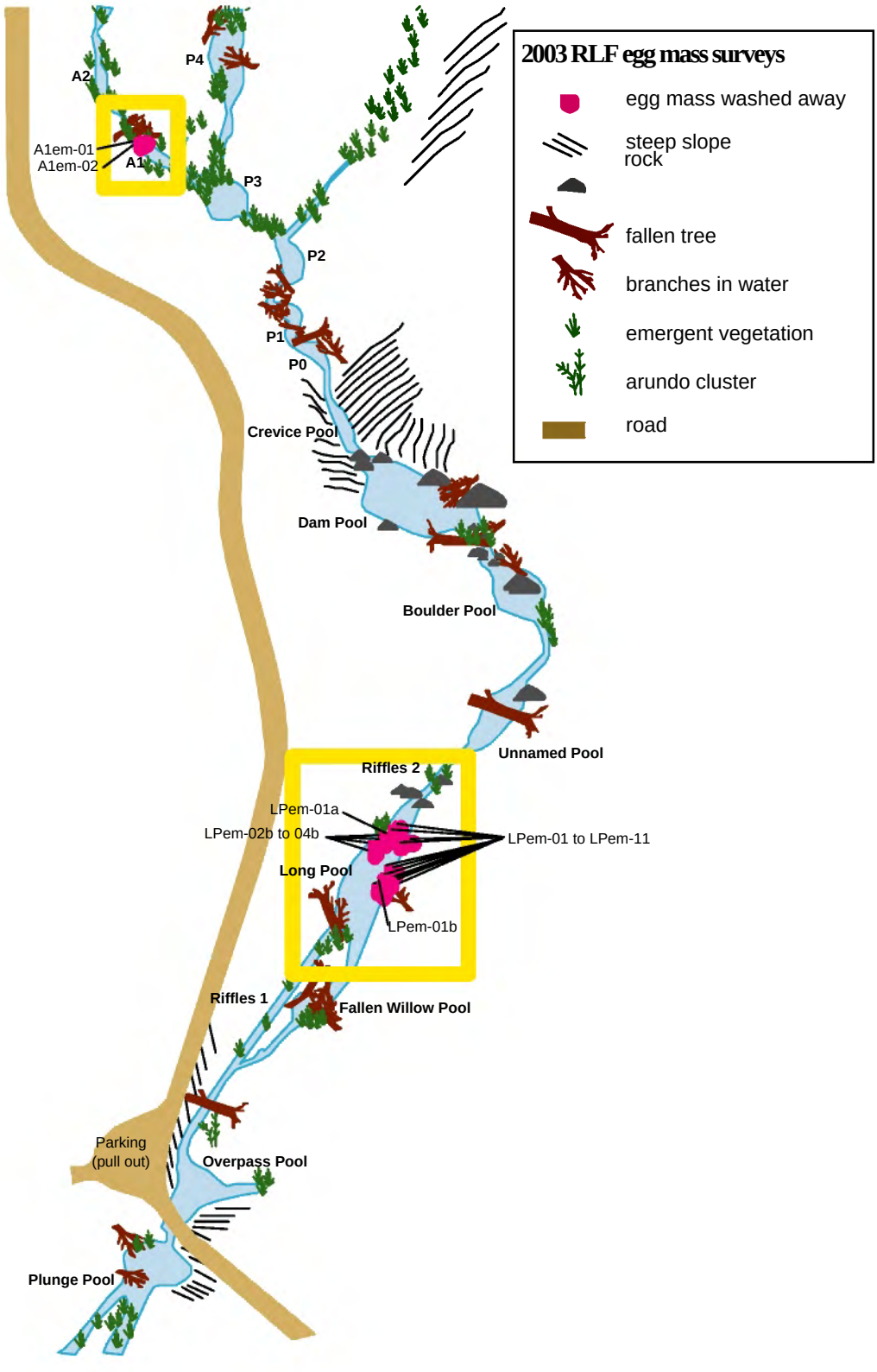
Survey Date	Survey Type	Pool	Age	Male / Female	Recapture	Animal ID	Length (mm)	Weight (g)	Notes
26-Aug-03	Nighttime, targeting adults	Pool 13	Adult		3 escaped				
		Pool 15	Adult		3 escaped				
		Pool D1	Adult		4 escaped				
			Adult	M	N		81	58	
			Adult	F	N		101	120	
			Adult		escaped				
		Pool MM1	Adult		4 escaped				
		Pool MM2	Adult		2 escaped				
27-Aug-03	Nighttime, targeting adults	Koi Pool	Adult		7 escaped				
			Adult	F	Y	044380284	86	120	
			Adult	F	N		80	66	
			Adult	F	Y	044583843	92	81	
		Tadpole Pool	Adult	M	Y	044127279	79	76	
			Adult	M	Y	053015038	83	86	
			Adult	M	Y	053357049	85	84	
			Adult	M	N		83	86	
			Adult		5 escaped				
			Adult	F	N		84	82	



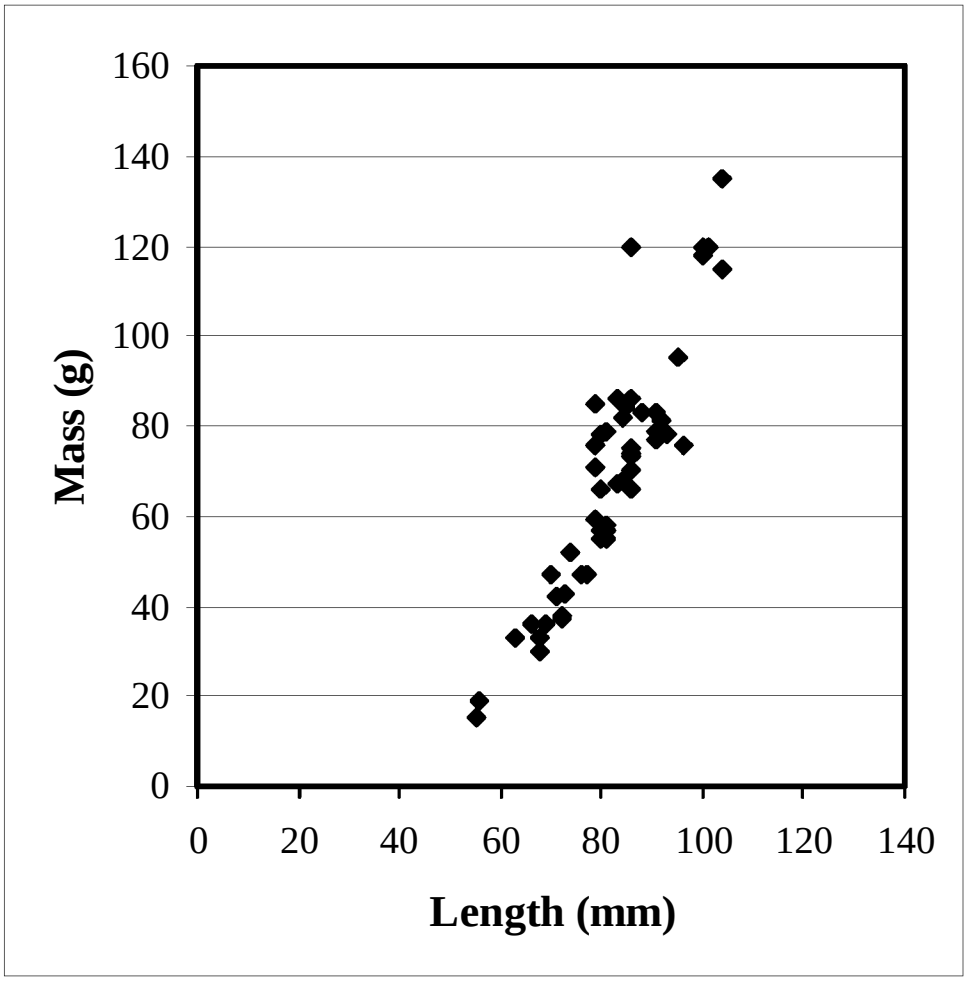
Appendix 1: Figure 1. San Francisquito Canyon survey areas.



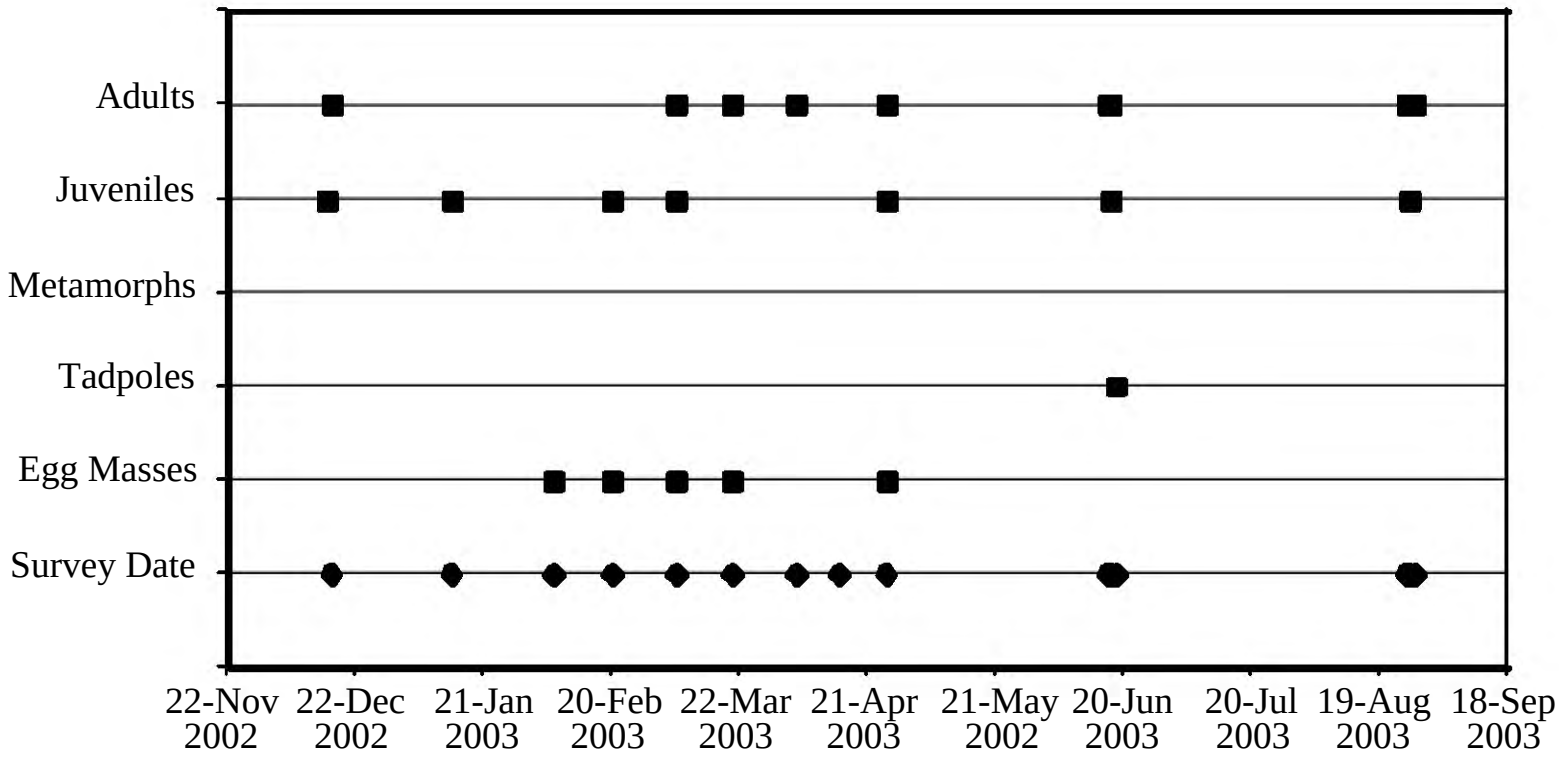
Appendix 1: Figure 2a. 2003 CRLF egg mass locations in northern Dam Reach. Yellow boxes indicate pools with egg masses (see table 3 for pool codes).



Appendix 1: Figure 2b. 2003 CRLF egg mass locations in southern Dam Reach. Yellow boxes indicate pools with egg masses (see table 3 for pool codes).



Appendix 1: Figure 3. Plot of length (snout-vent-length) versus mass for all captured adult and juvenile CRLF (N = 79). Frogs <60mm in length were recorded as juveniles.



Appendix 1: Figure 4. CRLF life stage observations by date. No metamorphs were detected in 2003.

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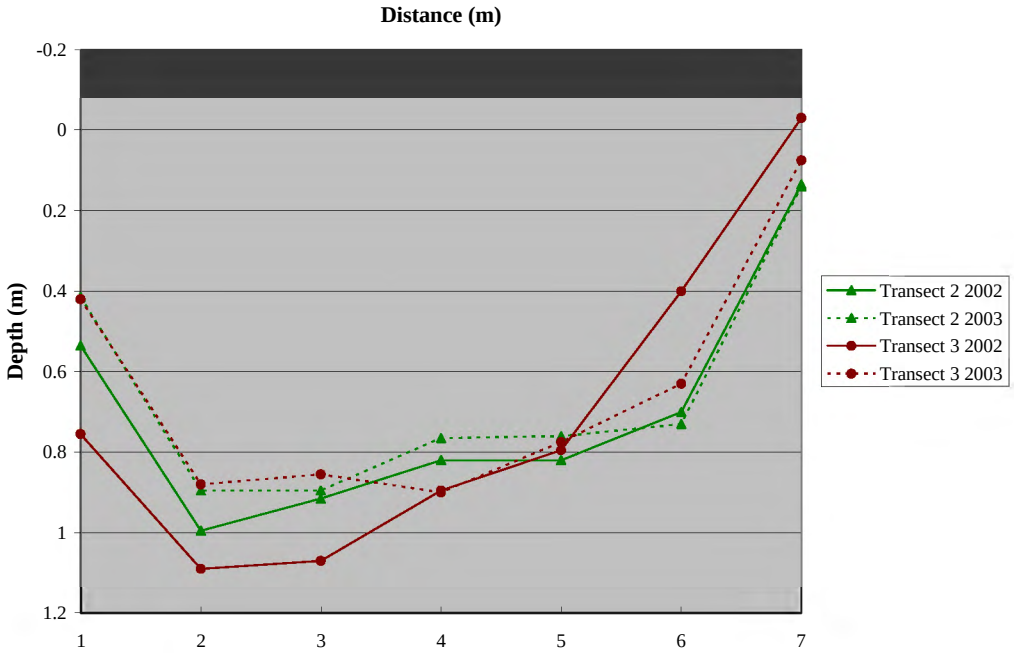
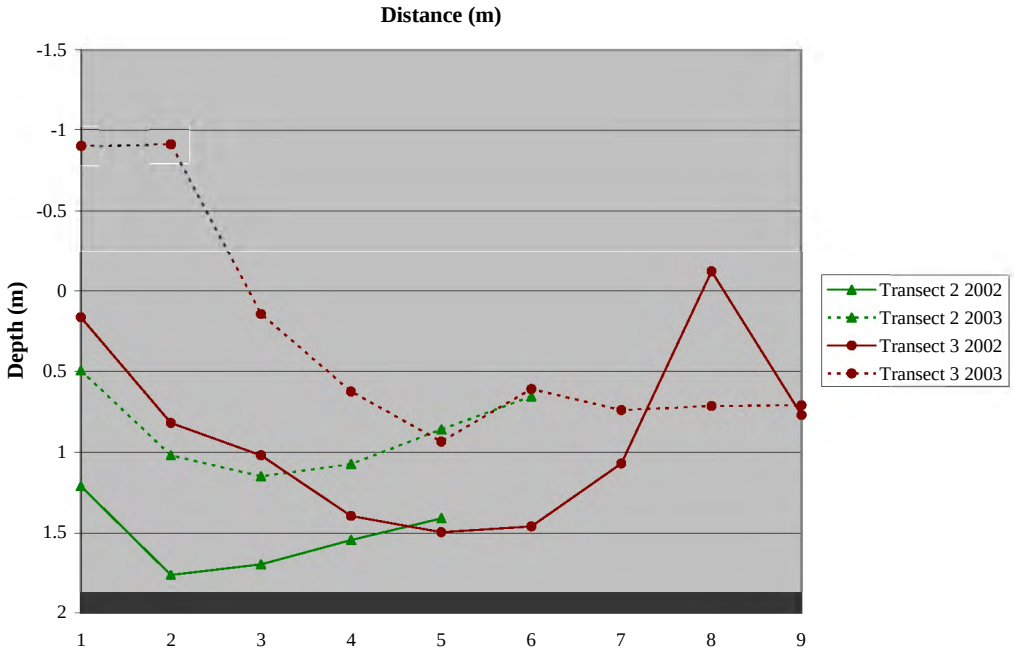
A.



B.



Appendix 1: Figure 5. (A) Long Pool (B) and Dam Pool morphology changes from 2002 - 2003. Depths were recorded by measuring from the sediment of the pool bottom to a designated "zero point" (Compton *et al.*, 2003).

Appendix 2

Unarmored Threespine Stickleback

Appendix 2: Table 1. Drinkwater Reach presence/absence of the following species within each 100m section. (Presence = 1, Absence = 0).

9/17/02	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	presence	absence	% Occupied
	arroyo chub	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	19	1	95%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	stickleback	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	11	9	55%
	common carp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	crayfish	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	18	2	90%
	goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	green sunfish	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	1	6	14	30%
	mosquitofish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
10/11/02	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**presence**	**absence**	**% Occupied**
	arroyo chub	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19	1	95%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	19	5%
	stickleback	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	10	10	50%
	common carp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	crayfish	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	19	1	95%
	goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	green sunfish	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	1	5	15	25%
	mosquitofish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
11/14/02	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**presence**	**absence**	**% Occupied**
	arroyo chub	0	1	1	1	1	1	1	1	1	1	1	1					1	1	1	1	15	5	75%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	0	1					0	0	0	0	1	19	5%
	stickleback	0	0	1	0	1	1	1	1	1	0	1	0					0	0	0	0	7	13	35%
	common carp	0	0	0	0	0	0	0	0	0	0	0	0					0	0	0	0	0	20	0%
	crayfish	1	1	1	1	0	1	1	1	1	1	1	1					1	1	1	1	15	5	75%
	goldfish	0	0	0	0	0	0	0	0	0	0	0	0					0	0	0	0	0	20	0%
	green sunfish	0	0	0	0	0	0	0	0	1	1	0	0					0	0	0	1	3	17	15%
	mosquitofish	0	0	0	0	0	0	0	0	0	0	0	0					0	0	0	0	0	20	0%
7/31/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**presence**	**absence**	**% Occupied**
	arroyo chub	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	5	75%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	19	5%
	stickleback	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	common carp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	crayfish	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6	14	30%
	goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	green sunfish	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1	7	13	35%
	mosquitofish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
11/13/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**presence**	**absence**	**% Occupied**
	arroyo chub		0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	5	75%
	Santa Ana sucker		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	stickleback		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	19	5%
	common carp		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	crayfish		0	0	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	13	7	65%
	goldfish		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	green sunfish		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	17	15%
	mosquitofish		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
12/10/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**presence**	**absence**	**% Occupied**
	arroyo chub		0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	3	85%
	Santa Ana sucker		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	stickleback		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	19	5%
	common carp	DRY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	crayfish		0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	1	15	5	75%
	goldfish		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%
	green sunfish		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	18	10%
	mosquitofish		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0%

Appendix 2: Table 2. Dam Reach presence/absence of the following species within each 100m section. (Presence = 1, Absence = 0).

		100m Section									OBSERVED		
9/17/02	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**presence**	**absence**	**% Occupied**
	arroyo chub	1	1	1	1	1	1	0	0	0	6	3	67%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	9	0%
	stickleback	1	1	1	1	1	1	1	0	0	7	2	78%
	common carp	0	0	0	0	0	0	0	0	0	0	9	0%
	crayfish	0	0	0	0	0	0	0	0	0	0	9	0%
	goldfish	0	0	0	0	0	0	0	0	0	0	9	0%
	green sunfish	0	0	0	0	0	0	0	0	0	0	9	0%
	mosquitofish	1	0	1	0	0	1	1	1	0	5	4	56%
10/11/02	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**presence**	**absence**	**% Occupied**
	arroyo chub	1	1	1	1	1	1	0	0	1	7	2	78%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	9	0%
	stickleback	1	1	1	1	1	1	1	1	1	9	0	100%
	common carp	0	0	0	0	0	0	0	0	1	1	8	11%
	crayfish	0	0	0	0	0	0	0	0	1	1	8	11%
	goldfish	0	0	0	0	0	0	0	0	0	0	9	0%
	green sunfish	0	0	0	0	0	0	0	0	0	0	9	0%
	mosquitofish	1	0	1	0	0	1	1	1	1	6	3	67%
11/15/02	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**presence**	**absence**	**% Occupied**
	arroyo chub	1	1	1	1	1	1	0	0	1	7	2	78%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	9	0%
	stickleback	1	1	1	1	1	1	1	1	1	9	0	100%
	common carp	0	0	0	0	0	0	0	0	0	0	9	0%
	crayfish	0	0	0	0	0	0	0	1	0	1	8	11%
	goldfish	0	0	0	0	0	0	0	0	0	0	9	0%
	green sunfish	0	0	0	0	0	0	0	0	0	0	9	0%
	mosquitofish	1	0	1	0	0	0	0	1	1	4	5	44%
8/1/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**presence**	**absence**	**% Occupied**
	arroyo chub	1	1	1	1	1	1	1	1	0	8	1	89%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	9	0%
	stickleback	1	1	1	1	1	1	0	0	0	6	3	67%
	common carp	0	0	0	0	0	0	0	0	0	0	9	0%
	crayfish	0	0	1	0	0	1	0	1	1	4	5	44%
	goldfish	0	0	0	0	0	0	0	0	0	0	9	0%
	green sunfish	0	0	0	0	0	0	0	0	0	0	9	0%
	mosquitofish	1	0	0	0	0	0	0	0	0	1	9	11%
11/13/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**presence**	**absence**	**% Occupied**
	arroyo chub	1	1	1	1	1	1	1	1	1	9	0	100%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	9	0%
	stickleback	1	1	1	1	1	0	0	0	0	5	4	56%
	common carp	0	0	0	0	0	0	0	0	0	0	9	0%
	crayfish	0	0	1	0	0	1	1	1	1	5	4	56%
	goldfish	0	0	0	0	0	0	0	0	0	0	9	0%
	green sunfish	0	0	0	0	0	0	0	0	0	0	9	0%
	mosquitofish	0	0	0	0	0	0	1	0	0	1	8	11%
12/10/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**presence**	**absence**	**% Occupied**
	arroyo chub	1	0	0	1	1	0	1	1	1	6	3	67%
	Santa Ana sucker	0	0	0	0	0	0	0	0	0	0	9	0%
	stickleback	1	1	1	1	1	1	0	0	0	6	3	67%
	common carp	0	0	0	0	0	0	0	0	0	0	9	0%
	crayfish	0	0	0	0	0	0	1	1	1	3	6	33%
	goldfish	0	0	0	0	0	0	0	0	0	0	9	0%
	green sunfish	0	0	0	0	0	0	0	0	0	0	9	0%
	mosquitofish	0	0	0	0	0	0	0	0	0	0	9	0%

Appendix 2: Table 3. Bouquet Canyon presence/absence of the following species within each 100m section. (Presence = 1, Absence = 0).

		100m Section																						OBSERVED		
7/30/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**presence**	**absence**	**% Occupied**
	stickleback	1	0	0	1	1	1	1	1	1	1	1	0	1	1	0	0	1	1	0	0	1	1	0	15	8	65%
	goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0%
	rainbow trout	1	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	8	15	35%
11/14/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**presence**	**absence**	**% Occupied**
	stickleback	0	1	1	1	1	0	1	0	0	0	1	0	0	0	1	1	1	1	0	1	1	1	0	13	10	57%
	goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0%
	rainbow trout	0	0	1	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0	1	1	0	9	14	39%
12/11/03	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**presence**	**absence**	**% Occupied**
	stickleback	0	0	0	1	1	1	1	1	0	0	1	1	0	1	1	0	0	0	0	0	1	1	0	11	12	48%
	goldfish	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	22	4%
	rainbow trout	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	1	1	0	7	16	30%

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Appendix 2: Table 4. Statistical analysis of presence/absence data for sticklebacks in Dam Reach.

Proportion of sampling units occupied analysis	2002		2003	
	Proportion	# sites	Proportion	# sites
Maximum occupancy at any one visit	1.000	9	0.667	6
Naïve PSO	1.000	9	0.667	6.0003
Estimated PSO	1.000	9	0.667	6.00
Standard error (SE)	0.000	0	0.159	1.43
upper 95% confidence limit	1.000	9	0.984	8.86
lower 95% confidence limit	1.000	9	0.350	3.15
detection probability	0.9259		0.9443	
Z-test for difference between years				
Z value	2.101			
Pr>Z	**0.0357**			

T-Test analysis (2 sample, unequal variance)	2002	2003
Average # sampling units with stickleback present	8.33	5.67
Standard error (SE)	0.67	0.33
T value	3.578	
P>t	**0.0386**	

Fishers exact test analysis	2002		2003		Probability
	# present	# absent	# present	# absent	
Sum of counts across visits	25	2	17	10	**0.0194**
Visit 1	7	2	6	3	1.000
Visit 2	9	0	5	4	0.0824
Visit 3	9	0	6	3	0.2059

Appendix 2: Table 5. Statistical analysis of presence/absence data for sticklebacks in Drinkwater Reach.

Proportion of sampling units occupied analysis (PSO)	2002		2003	
	Proportion	# sites	Proportion	# sites
Maximum occupancy at any one visit	0.55	11	0.05	1
Naïve PSO	0.65	13	0.05	1
Estimated PSO	0.6891	13.782	-	-
Standard error (SE)	0.1187	2.374	-	-
upper 95% confidence limit	0.9265	18.53	-	-
lower 95% confidence limit	0.4517	9.034	-	-
detection probability	0.7081		-	
Z-test for difference between years				
Z value	3.807			
Pr>Z	**0.0001**			

T-Test analysis (2 sample, unequal variance)	2002	2003
Average # sampling units with stickleback present	9.333333	0.333333
Standard error (SE)	1.2019	0.3333
T value	7.216	
P>t	**0.0125**	

Fishers exact test analysis	2002		2003		Probability
	# present	# absent	# present	# absent	
Sum of counts across visits	28	28	1	57	**0.0001**
Visit 1	11	9	0	20	0.0001
Visit 2	10	10	1	18	0.0033
Visit 3	7	9	0	19	0.0017

Appendix 2: Table 6. Statistical analysis of presence/absence data for sticklebacks in Bouquet Canyon.

Proportion of sampling units occupied analysis (PSO)	2003	
	Proportion	# sites
Maximum occupancy at any one visit	0.65	15
Naïve PSO	0.913	21
Estimated PSO	0.9921	22.8183
Standard error (SE)	0.0471	1.0833
upper 95% confidence limit	1.0863	24.9849
lower 95% confidence limit	0.8979	20.6517
detection probability	0.5697	

Appendix 2: Table 7. Comparison of general biological and physical characteristics between survey sites in 2003.

Characteristic	Dam Reach	Drinkwater Reach	Bouquet Canyon
Stickleback PSO average (range)	63% (56-67%)	3% (0-5%)	57% (48-65%)
Santa Ana Sucker PSO average (range)	0% (0-0%)	2% (0-5%)	no data
Chub PSO average (range)	85% (67-100%)	78% (75-85%)	no data
Mosquitofish PSO average (range)	7% ()-11%)	0% (0-0%)	no data
Green Sunfiish PSO average (range)	0% (0-0%)	20% (10-35%)	no data
Goldfish PSO average (range)	0% (0-0%)	0% (0-0%)	1% (0-4%)
Common Carp PSO average (range)	0% (0-0%)	0% (0-0%)	no data
Rainbow Trout PSO (range)	0% (0-0%)	0% (0-0%)	35% (30-39%)
Crayfish PSO average (range)	44% (33-56%)	57% (30-75%)	no data
Invasive Species Densities *	LOW	HIGH	LOW
Ich detected	yes	no	no
Santa Ana Suckers detected	no	yes	no
Red-Legged Frogs detected	yes	yes (1 frog)	no
Pond Turtles detected	yes	yes	no
Garter Snakes detected	no	no	no
Permanent water	yes	yes	no
Conductance (average)	960µs	372µs	no data
Nutrient levels	similar	similar	no data

* High = had one or more species with average PSO >50%

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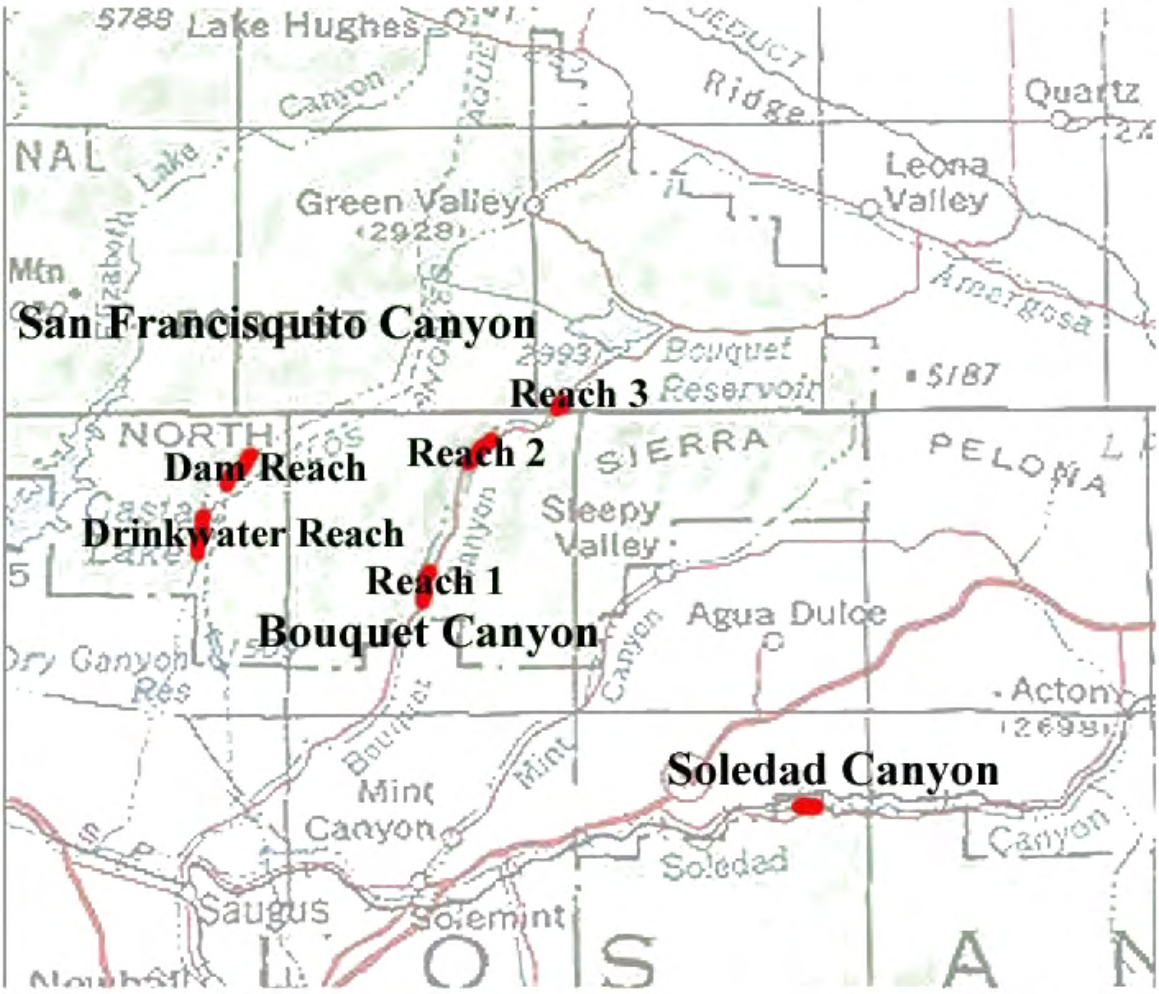
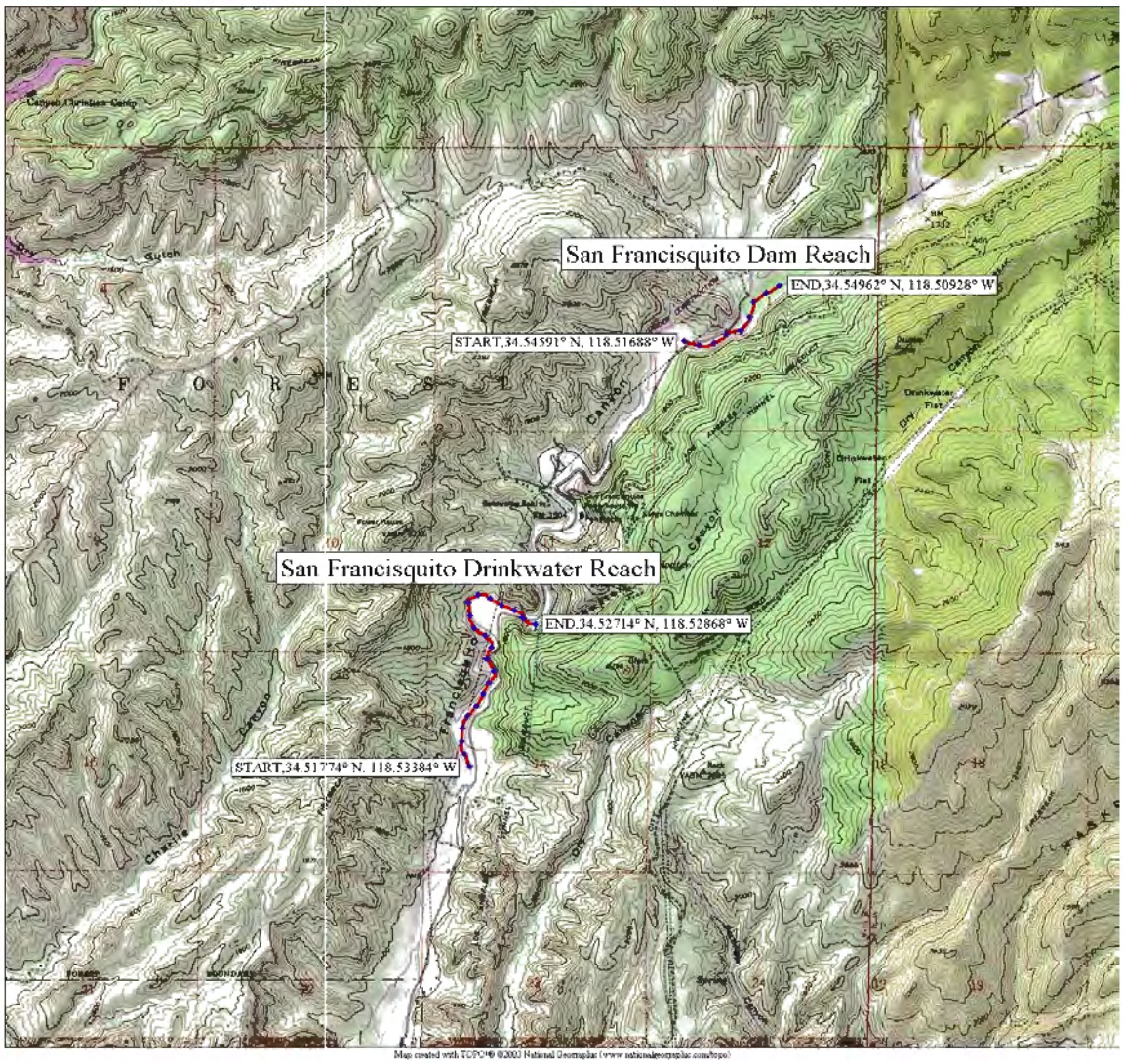
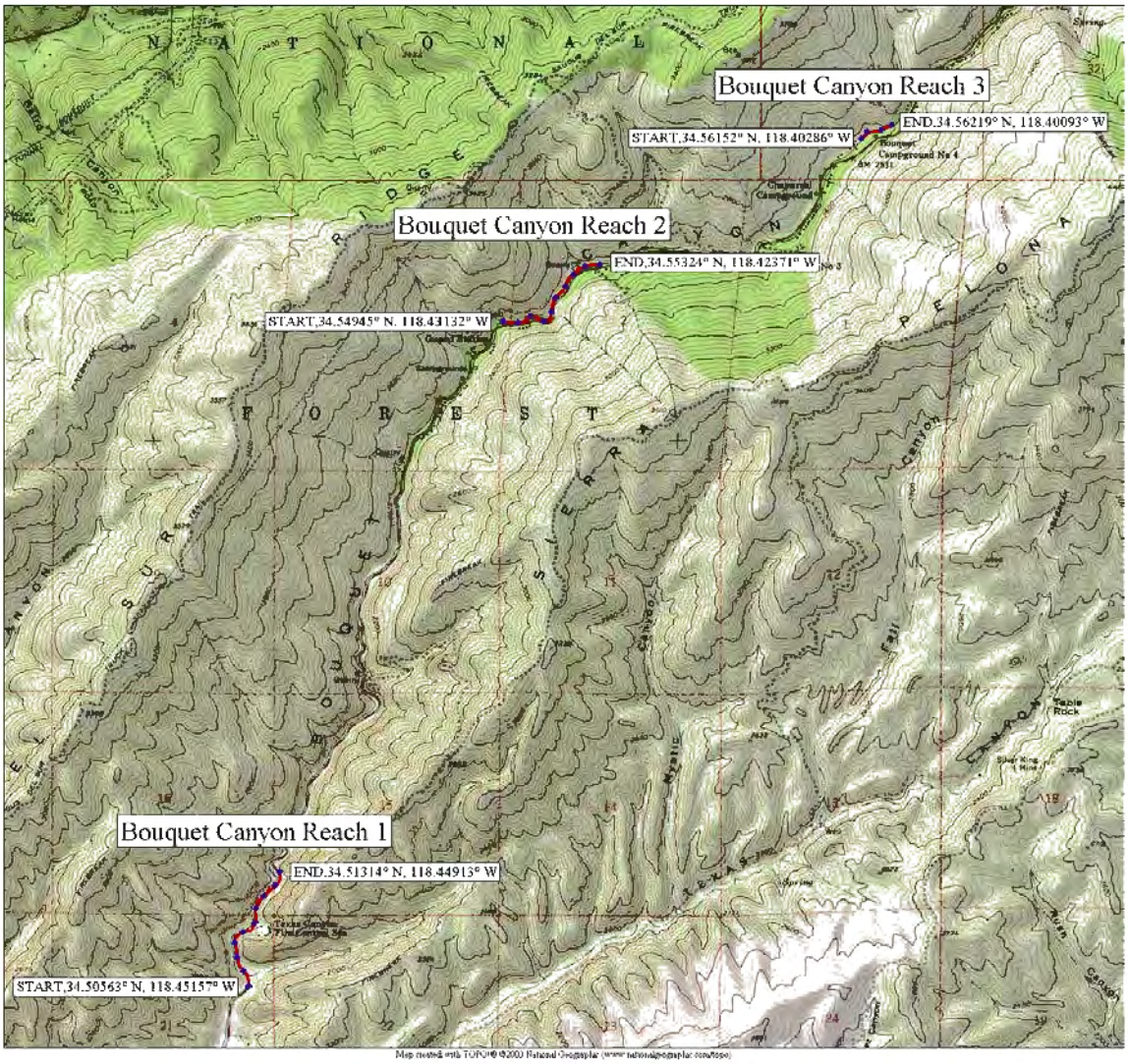


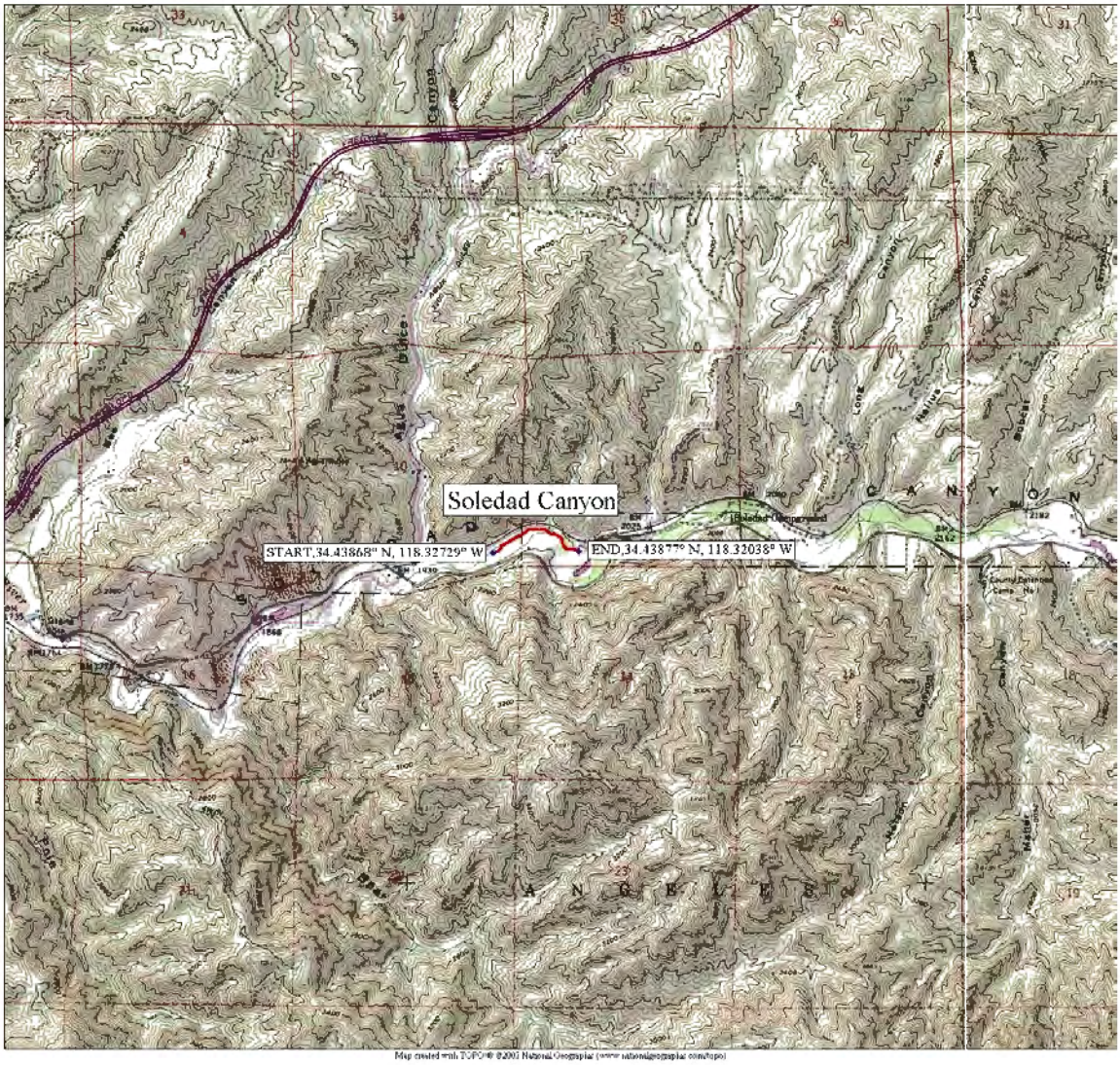
Appendix 2: Figure 1. Overview map of all UTS sites.


San Francisquito Dam Reach
END,34.54962° N, 118.50928° W
START,34.54591° N, 118.51688° W
San Francisquito Drinkwater Reach
END,34.52714° N, 118.52868° W
START,34.51774° N, 118.53384° W

Appendix 2: Figure 2. Map of San Francisquito Canyon sites.



Appendix 2: Figure 3. Map of Bouquet Canyon sites.



Appendix 2: Figure 4. Map of Soledad Canyon site.

Appendix 3

Water Quality

Appendix 3: Table 1. Summary of TidbiT temperature loggers.

Site	Start	End	Average	Minimum	Maximum
Dam Reach - Bridge Pool	6/10/2002	11/15/2002	16.40	9.10	24.10
Dam Reach - Long Pool	6/10/2002	11/15/2002	16.90	11.30	22.00
Dam Reach - Dam Pool	6/10/2002	1/24/2003	14.90	1.30	20.60

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Appendix 3: Table 2. Nutrient values pre and post burn for Dam Reach and Drinkwater Reach. Values marked with a"<" symbol are at or below the lowest detectable levels.

DAM REACH

NUTRIENT	12/19/00	7/22/02	9/25/02	12/16/02	10/20/03
NITROGEN AMMONIA DISSOLVED (MG/L AS N)	<0.04	<0.04	<0.04	0.854	<0.04
NITROGEN AMMONIA PLUS ORGANIC TOTAL (MG/L AS N)	Not Tested	0.21	0.22	80.135	Not Tested
NITROGEN NITRITE PLUS NITRATE DISSOLVED (MG/L AS N)	<0.03	<0.04	<0.05	4.48	0.06
NITROGEN, NITRITE, DISSOLVED, MG/L AS N	<0.006	<0.008	<0.008	0.124	<0.008
PHOSPHORUS ORTHOPHOSPHATE DISSOLVED (MG/L AS P)	<0.02	<0.03	<0.03	0.53	<0.03
PHOSPHORUS TOTAL (MG/L AS P)	Not Tested	0.048	0.039	16.928	0.0426
CARBON ORGANIC DISSOLVED (MG/L AS C)	1.3	Not Tested	Not Tested	36.086	2.2188
IRON DISSOLVED (UG/L AS FE)	10	10	Not Tested	42.85	Not Tested
MANGANESE DISSOLVED (UG/L AS MN)	3.2	1.4	Not Tested	175.53	Not Tested

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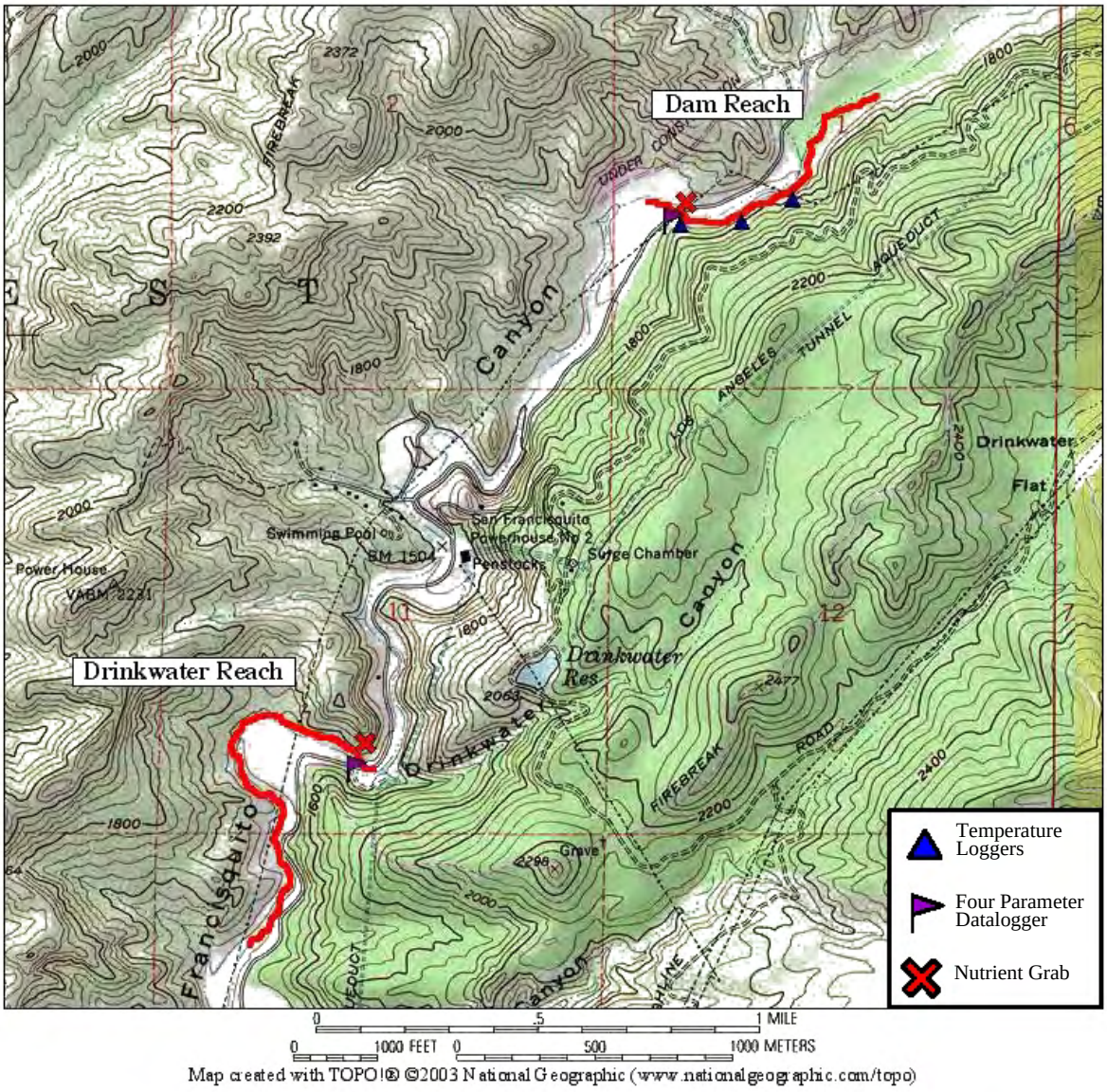
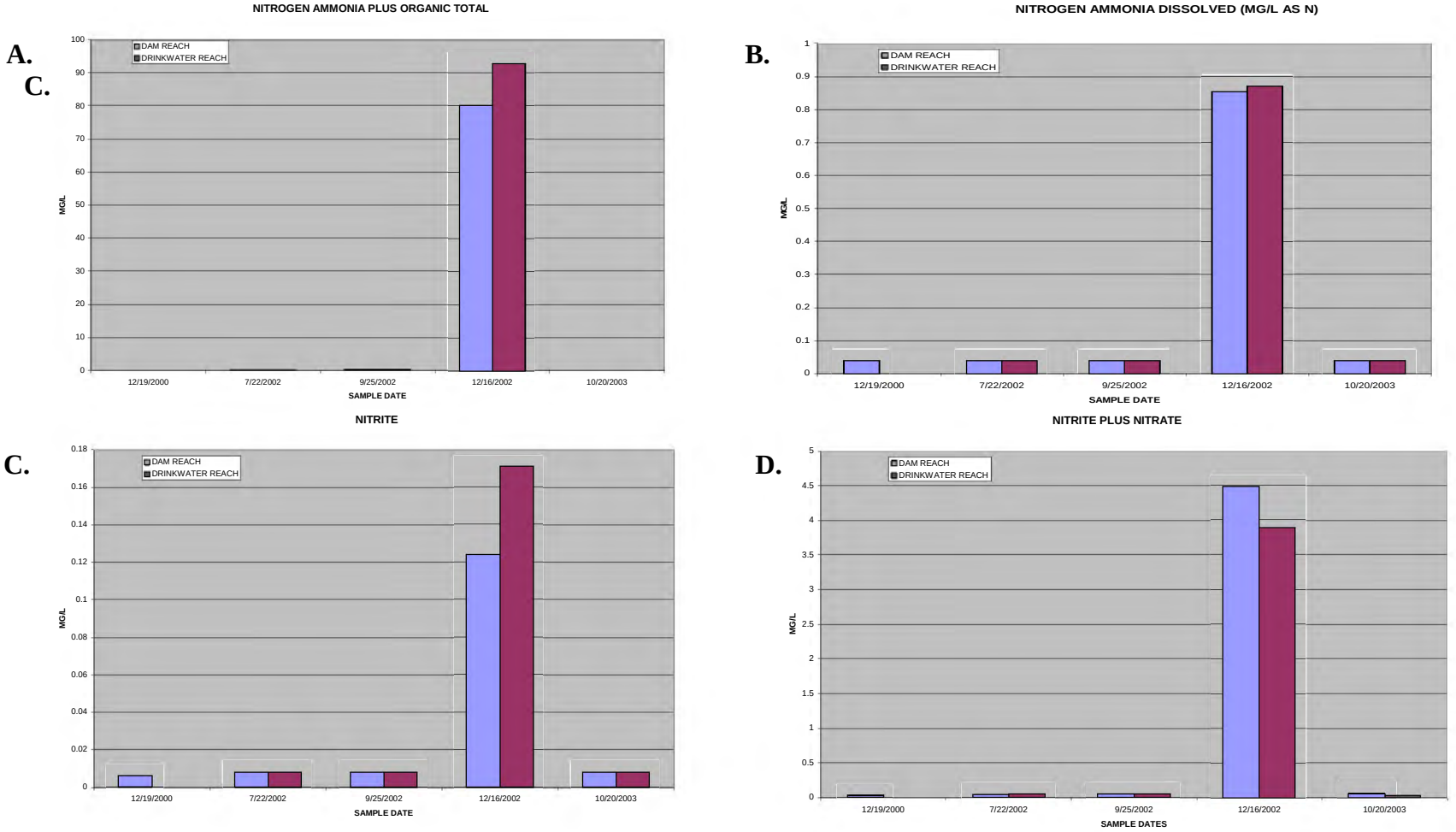
DRINKWATER REACH

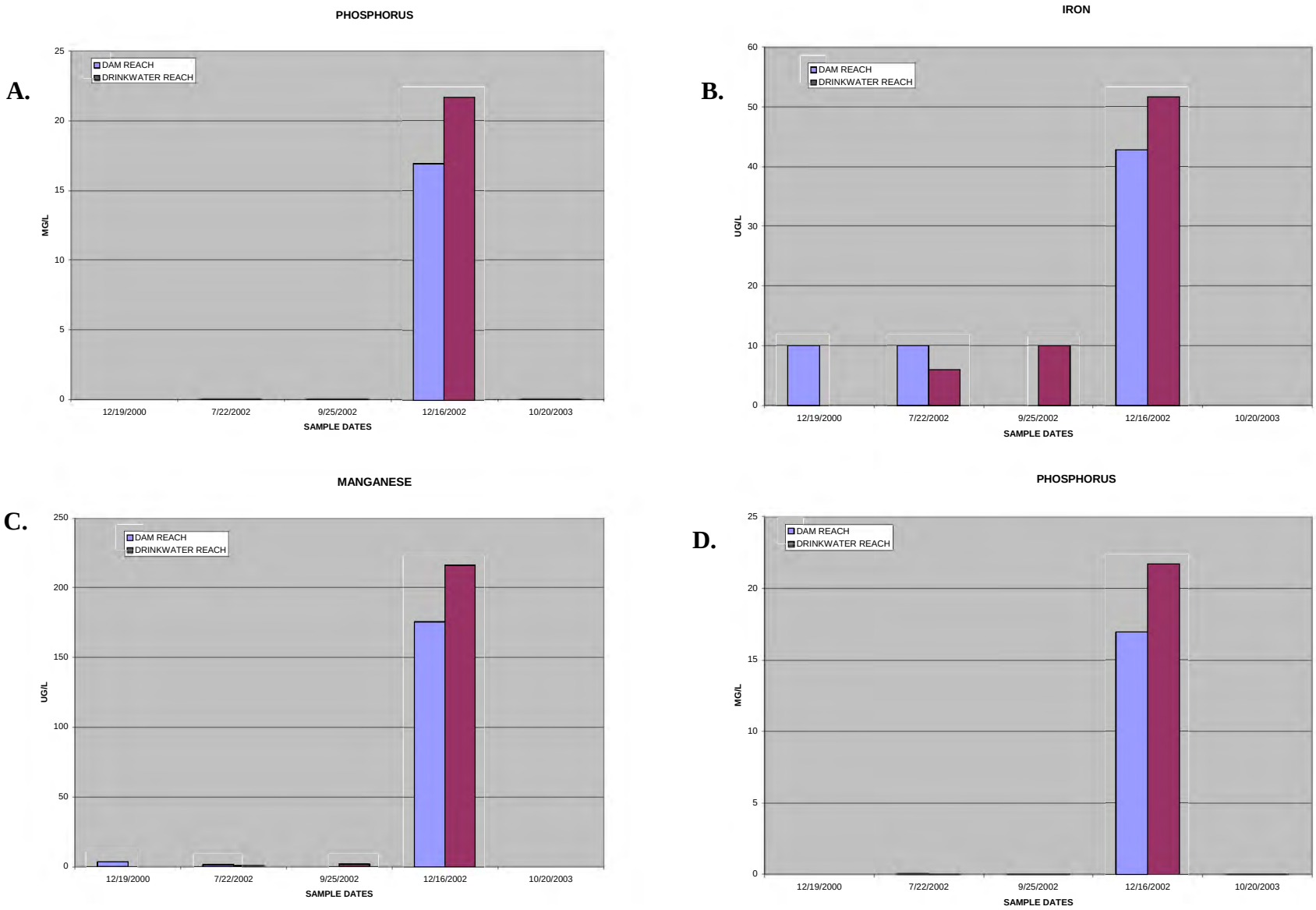
NUTRIENT	7/22/02	9/25/02	12/16/02	10/20/03
NITROGEN AMMONIA DISSOLVED (MG/L AS N)	<0.04	<0.04	0.871	<0.04
NITROGEN AMMONIA PLUS ORGANIC TOTAL (MG/L AS N)	0.17	0.34	92.84	Not Tested
NITROGEN NITRITE PLUS NITRATE DISSOLVED (MG/L AS N)	<0.05	<0.05	3.89	<0.035
NITROGEN, NITRITE, DISSOLVED, MG/L AS N	<0.008	<0.008	0.171	<0.008
PHOSPHORUS ORTHOPHOSPHATE DISSOLVED (MG/L AS P)	<0.02	<0.02	0.662	<0.013
PHOSPHORUS TOTAL (MG/L AS P)	0.028	0.027	21.677	0.0244
CARBON ORGANIC DISSOLVED (MG/L AS C)	Not Tested	Not Tested	37.73	1.6633
IRON DISSOLVED (UG/L AS FE)	6	10	51.71	Not Tested
MANGANESE DISSOLVED (UG/L AS MN)	0.9	1.8	215.93	Not Tested

Appendix 3: Figure 1. Map of Dam and Drinkwater Reaches showing water sample locations.





Appendix 3: Figure 2. Plot of recorded values in milligrams per liter for nutrients on 5 dates (12/19/00, 7/22/02, 9/25/02, 12/16/02, 10/20/03) for the Dam and Drinkwater Reach of San Francisquito Canyon; (A) ammonia plus organic nitrogen, (B) dissolved ammonia, (C) nitrite, (D) nitrite plus nitrate.



Appendix 3: Figure 3. Plot of recorded values in milligrams per liter for nutrients on 5 dates (12/19/00, 7/22/02, 9/25/02, 12/16/02, 10/20/03) for the Dam and Drinkwater Reach of San Francisquito Canyon; (A) phosphorus, (B) iron, (C) manganese, (D) phosphorus.

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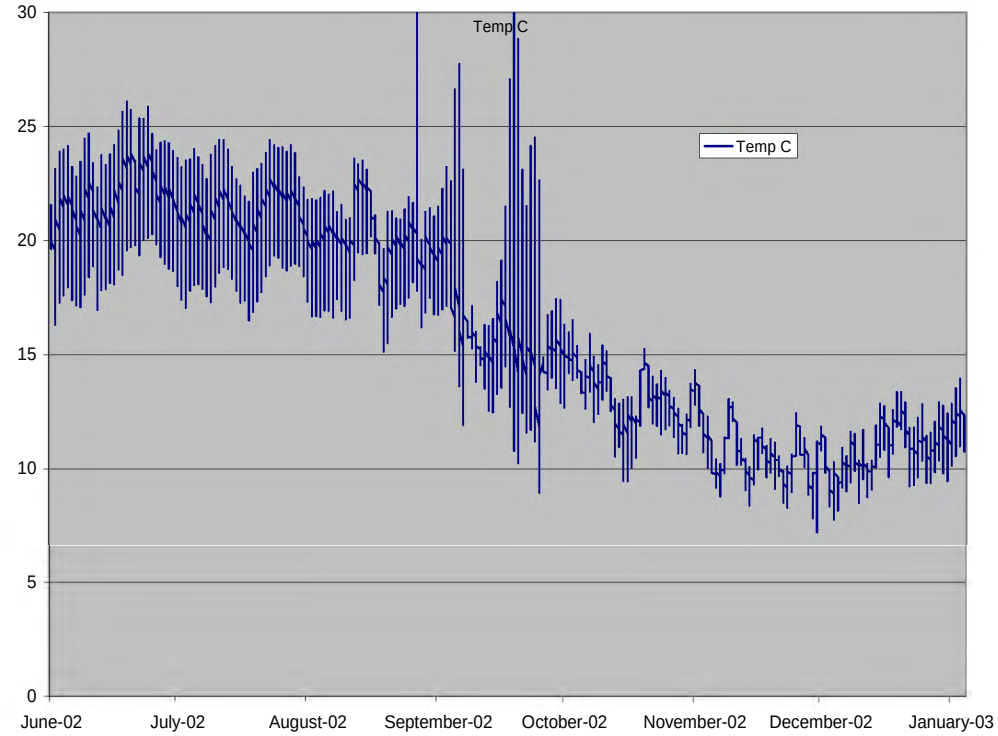
A.



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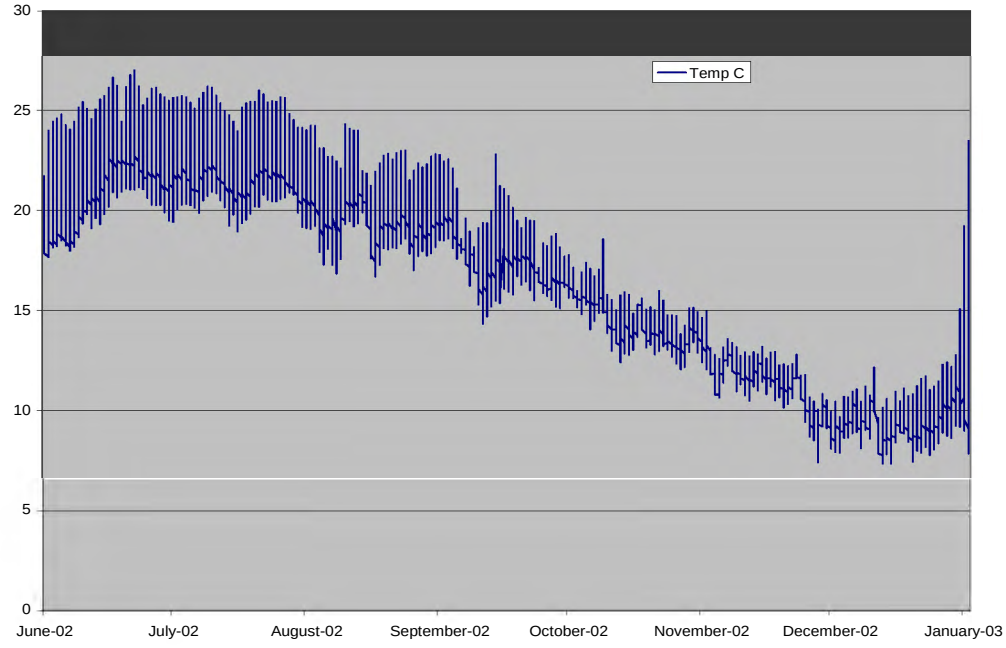
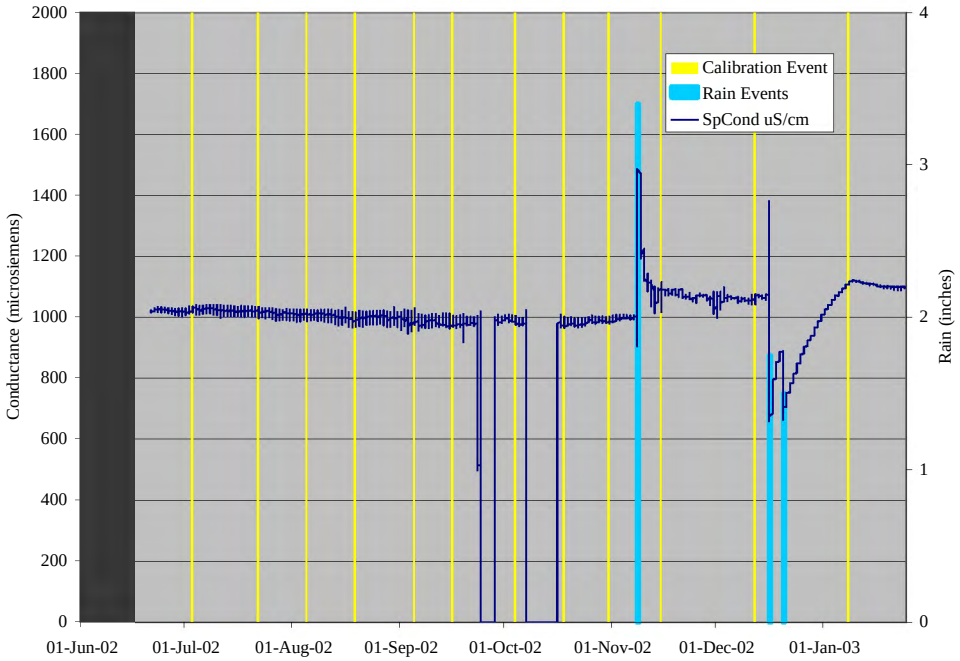


Appendix 3: Figure 4. Plot of hourly temperature readings recorded from 05/02 to 02/03. Data recorded by YSI 600XLM in (A) Dam and (B) Drinkwater Reaches of San Francisquito Canyon. Extreme values are from probe being exposed to air as water level dropped.

A.



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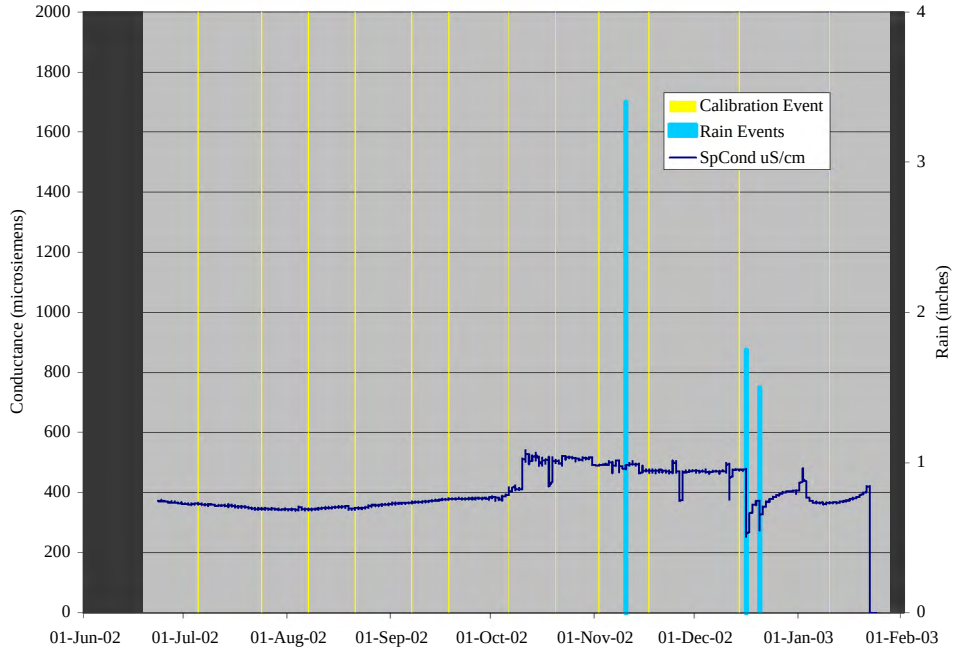
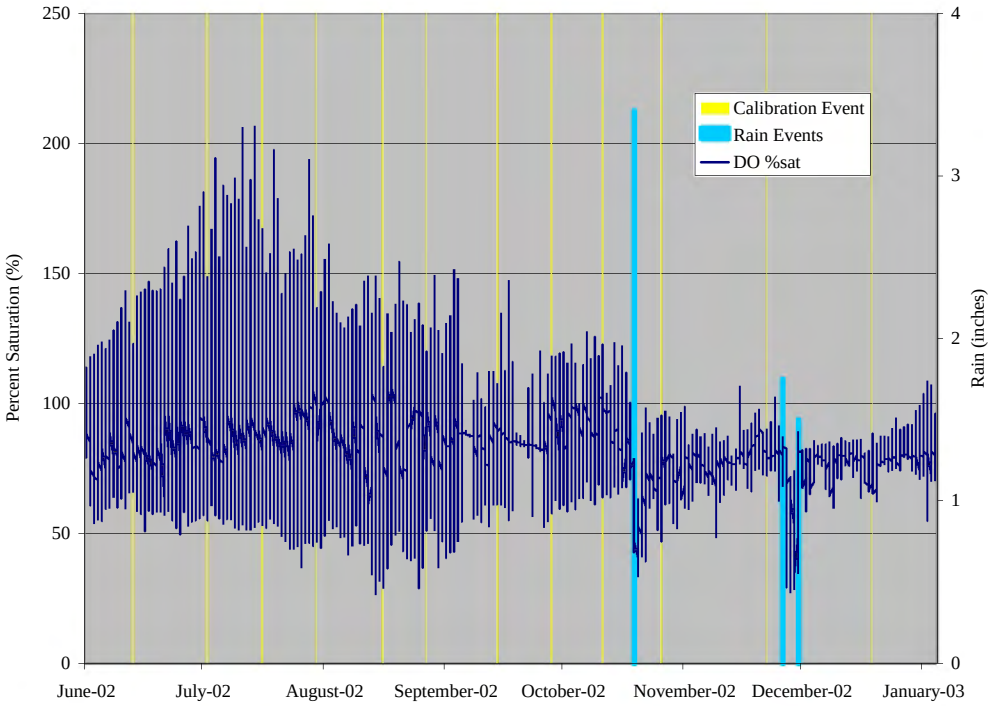
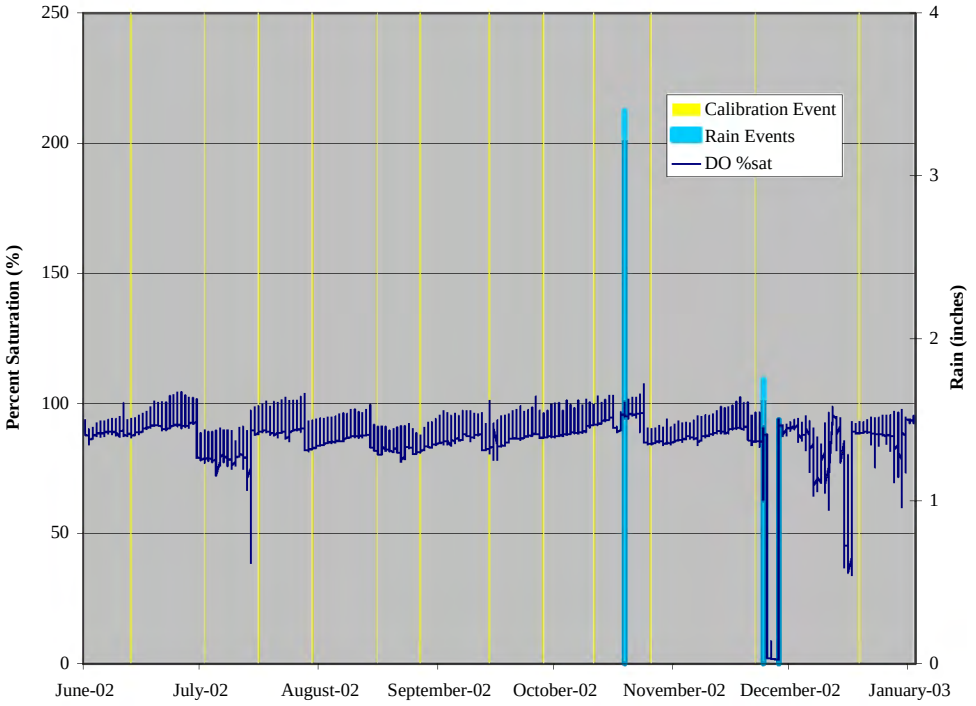


Appendix 3: Figure 5. Plot of hourly conductivity readings recorded from 05/02 to 02/03. Blue bars indicate rainfall in inches. Yellow Bars indicate re-calibration of the instrument. Data recorded by YSI 600XLM in (A) Dam and (B) Drinkwater Reaches of San Francisquito Canyon.

A.

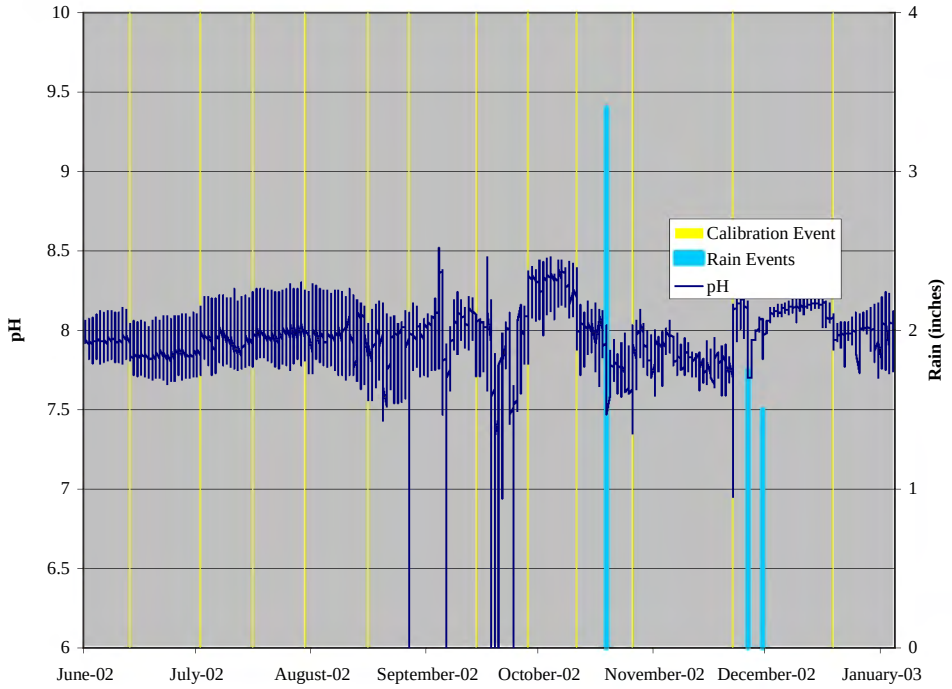


B.

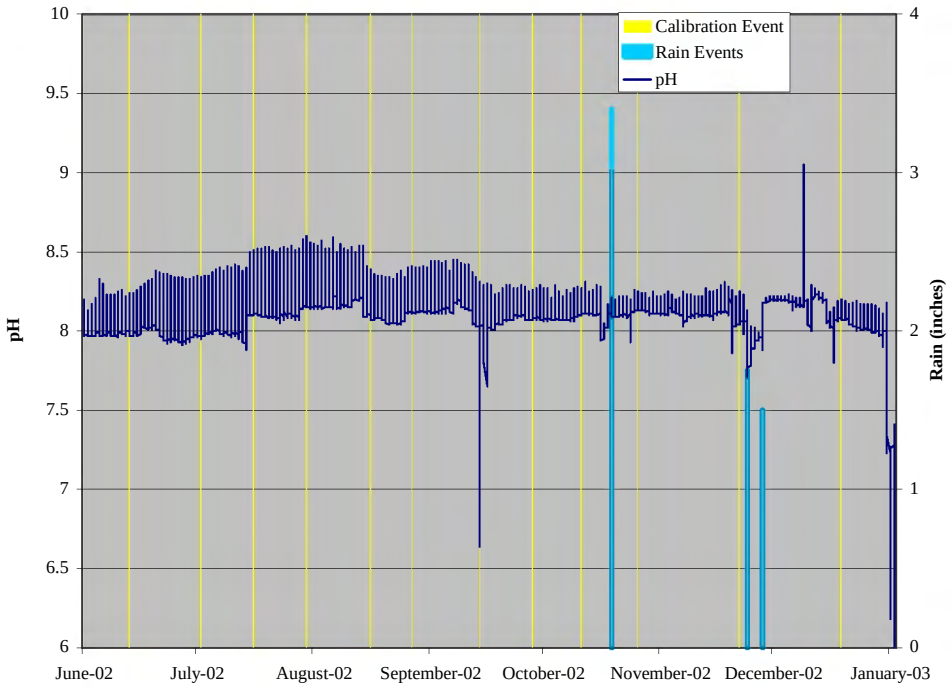


Appendix 3: Figure 6. Plot of hourly dissolved oxygen readings recorded from 05/02 to 02/03. Blue bars indicate rainfall in inches. Yellow Bars indicate re-calibration of the instrument. Data recorded by YSI 600XLM in (A) Dam and (B) Drinkwater Reaches of San Francisquito Canyon.

A.



B.



Appendix 3: Figure 7. Plot of hourly pH readings recorded from 05/02 to 02/03. Blue bars indicate rainfall in inches. Yellow Bars indicate re-calibration of the instrument. Data recorded by YSI 600XLM in (A) Dam and (B) Drinkwater Reaches of San Francisquito Canyon.